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Patents ADP number *(if you know it)*

7468762001

If the applicant is a corporate body, give the country/state of its incorporation

4. Title of the invention

MODULAR BUILDINGS

5. Name of your agent *(if you have one)*

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MODULAR BUILDINGS

The present invention relates to modular buildings and more particularly to their structure, the method of their construction and interconnection.

It is well known to provide for portable modular building in circumstances where accommodation is needed in an emergency or on a temporary basis. Such buildings have to be rapidly and easily assembled to meet demand for emergency habitable structures in times, for example, of natural or other disasters. In addition such buildings are often required in remote locations by workers employed in the construction industry where temporary accommodation is needed during the term of the construction project.

There is a need for an all-purpose modular building system that can be exploited by both the residential and commercial construction sectors of industry. To date, portable and prefabricated buildings designs have not proved suitable for application in both sectors. Modular buildings have the advantages that they are easy and quick to erect, dismantle or relocate, are readily transportable, and flexible in that they are reconfigurable to meet changing requirements in size or needs. Unfortunately existing designs of such buildings are generally of a temporary nature and are not suited to long-term or permanent applications.

Existing modular buildings suffer from several disadvantages including: racking which causes wear and tear to the structure of the building and often leads to leaks, creaks and structural damage; condensation; inadequate interior temperature control; ineffective noise insulation; and an excessive ingress of dirt and dust (particularly in environments such as construction sites).

It is an object of the present invention to obviate or mitigate the aforesaid disadvantages and to provide for a modular building construction that has improved life expectancy so that it meets the requirements of more permanent structures whilst maintaining the benefits of its modular nature. The term "building module" is used hereinafter to refer to an inhabitable building block that can be used as living quarters, an office, a conference room, a lavatory or washroom or another room that forms part of a larger building structure.

According to a first aspect of the present invention there is provided a modular building structure comprising a service module defining a plurality of connection nodes for connection to separate building modules, the service module containing apparatus for the supply and distribution of at least one mains service to the building modules, each building module being free-standing, pre-fitted for its intended use and connected to one of said connection nodes and to said supply of at least one mains service.

The modular structure of the present invention provides for a very flexible arrangement in that once the service module has been installed on site the building modules can then be connected thereto in the desired number and fashion. If there is a demand for more building modules these can be simply added without the need to lay further mains service supplies. Similarly, removal of a particular building module is also a simple operation. As the mains service supply is contained within the service module the need for preliminary ground excavation is eliminated. Moreover little or no foundations are required.

The service module is preferably in the form of a corridor walkway linking the building modules. The corridor may conveniently be provided with floor and ceiling cavities in which the mains service supplies are routed. Preferably one building module is a dedicated plant room that feeds the mains supply service to the service module.

The service module is preferably sectional so that it can be extended or shortened to provide more or less connection nodes as required. More than one service module may be provided and they may extend in transverse directions. The mains service may be electricity, waste disposal, air conditioning, water etc. In the case of waste disposal, each service module is provided with a holding tank and is connected to a lavatory or wash area of an adjacent building module. Preferably the holding tanks of adjacent sections of a service module are connected by a suction waste pipe. The arrangement eliminates the need for gravity operated waste disposal. In the case of air conditioning each service module is preferably fitted with a heat exchanger and has an external pump for evacuation of warm air. Each building module also has its

own heat exchanger that is connected to the pump and heat exchanger of the adjacent service module.

Preferably each adjoining pair of building modules or service modules have apparatus for connecting adjacent modules, the apparatus comprising a housing defining apertures that extend into the structure of each module and a flexible grommet that is received in each aperture and bridges the two modules, the flexible grommet being supported on a fixing element that is secured to each of the modules.

According to a second aspect of the present invention there is provided a building module comprising an inner shell of planar walls connected at its corners by corner connection assemblies to define a box structure, an exterior framework assembly connected to the inner shell and the corner connection assemblies for supporting the box structure, an outer shell and a material in-fill in a cavity defined between the inner and outer shell, the exterior framework assembly being disposed principally between the inner and outer shells.

The corner connection assemblies preferably comprise first and second clamping members, the first clamping member being disposed on the interior corner of the box structure and the second clamping member being disposed on the exterior corners of the box structure, the clamping members being connected together so as to clamp the adjacent planar walls together. The corner clamping members may have protruding elements that engage in recesses in the planar walls of the inner shell.

The exterior framework assembly preferably comprises a plurality of frames that are spaced at intervals along the length of the module. Each frame comprises a four-sided assembly, each frame member of the assembly being connected to the exterior of a wall of the inner shell. Preferably each frame member is of top-hat configuration having three sides that define a channel which, when assembled, is closed by the respective wall of the inner shell to provide a strong box like structure. The closed channel is preferably filled with support material.

The corner connection assemblies may further comprise at least one corner bracket that is connected to the exterior of the second corner clamping member.

The building module may have an end frame disposed over exposed end edges of the box section. The end frame preferably comprises first and second portions that form a sandwich with a respective wall of the inner shell by receiving the end of the wall and clamping it therebetween. The end frame preferably provides attachment points for the outer shell and other ancillary structures and may provide water drainage means.

The outer shell preferably comprises a plurality of planar cladding panels

Preferably each corner of the module is fitted with a longitudinal bearer plate that extends along the length of the module and is connected to the exterior framework and the corner connection assemblies to provided lateral support therefor. The longitudinal bearer plates preferably interconnect adjacent panels of the outer shell.

Preferably there is provided a super-structure frame assembly that is connected to the inner shell and provides lifting points for the module. The super-structure assembly may also comprise jacking legs by which the module may be raised or lowered relative to the ground. The super structure may have pads that engage in recesses on the exterior walls of the inner shell.

Each module is preferably provided with a suspended floor and ceiling so as to define floor and ceiling cavities with upper and lower walls of the inner shell, the cavities being fitted with mains service supply apparatus.

According to a third aspect of the present invention there is provided a method for constructing a building module, the method comprising the steps of: preparing a site on which the building structure is to be located; installing a service module on the prepared site, the service module defining a plurality of connection nodes for connection to separate building modules; installing at least one mains supply service to the service module; connecting at least one pre-constructed building module to a connection node and connecting it to the mains supply service of the service module.

According to a fourth aspect of the present invention there is provided apparatus for connecting adjacent building modules, the apparatus comprising a housing defining apertures that extend into the structure of each building module and

a flexible grommet that is received in each aperture and bridges the two building modules, the flexible grommet being supported on a fixing element that is secured to each of the building modules.

The housing preferably further comprises an access chamber that is open to the inside of the building module so as to facilitate insertion of the fixing element and flexible grommet.

Preferably the apparatus for connecting adjacent building modules is disposed in a floor or ceiling cavity of the building module.

Specific embodiments of the present inventions will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a perspective view of a modular building structure of the present invention constructed from a plurality of interconnected modules with certain panels removed for clarity;

Figure 2 is a perspective view of a building module shown partially cut-away;

Figure 3 is a perspective view of interior lining panels of the module shown in figure 2;

Figure 4 is a side view of an interior lining panel of figure 3 showing surface detail;

Figure 4a is a enlarged view of part of the panel of figure 4;

Figure 5 is a perspective view of an outer corner joining clamping member of the module shown in figure 2;

Figure 6 is a perspective view of an inner corner joining clamping member;

Figure 7 is a sectioned end view of an assembly of the interior lining panels and the corner joining clamping members of figures 5 and 6;

Figure 8 is a perspective view of a corner bracket of the module;

Figure 9 is a cross-sectioned side view showing the corner bracket connected to the assembly of figure 7;

Figure 10 is a plan view of part of a top hat frame shown before pressing;

Figure 11 is a perspective fragmentary view of the top hat frame of figure 10 shown after pressing;

Figure 12 is a schematic perspective view of a module showing the interior lining panels and a plurality of top hat frame assemblies;

Figure 13 shows an end view of a top hat frame assembly;

Figure 14 is a perspective view of an end frame assembly shown with an interior lining panel;

Figure 15 is a cross-sectioned end view of the assembly of figure 14;

Figure 16 is a perspective view of a corner bearer member forming part of the module of figure 2;

Figure 17 is a cross-sectioned side view showing a corner bearer member of figure 16 connected to a first part of the outer corner joining clamping member of figure 5;

Figure 18 is a perspective view of a corner of the assembled building module of figure 2 shown partly cut-away for clarity;

Figure 19 is a section through part of the building module of figure 2 showing a super-structure assembly;

Figure 20 is a perspective view of super-structure assembly;

Figure 21 is a sectioned side view of the intersection of two modules showing connecting points and a fixing assembly;

Figure 22 is a side view of a grommet of the fixing assembly shown in figure 21;

Figure 23 is a side view of a grommet housing of the connecting point shown in figure 21;

Figure 24 is a sectioned side view of the grommet housing of figure 23 shown in engagement with the end frame;

Figure 24a to 24e show details of a jacking mechanism and a half grommet fastening on the super-structure assembly of figure 20;

Figure 25 is a diagrammatic perspective view of an assembled building module;

Figure 25a is a diagrammatic perspective view of the module of figure 25 shown with end walls fitted;

Figure 26 is a perspective view of a corridor of the modular building, the corridor being shown partially cut-away and connected to the building module of figure 2;

Figure 27 is a perspective view of a support frame assembly of the corridor of figure 26;

Figure 28 is a front view of a section through a combined ceiling and floor support frame; showing the interconnection of a corridor to modules at each side;

Figure 28a is a front view of a section through a separate ceiling support frame;

Figure 28b is a front view of a section through a separate floor support frame

Figure 29 is an end view of a furbished corridor module with end walls removed for clarity;

Figure 30 is a front view showing a semi-flat pack building module;

Figures 30a-c show front and side and perspective views of an interconnection between parts of the flat pack module of figure 30;

Figure 31 is a schematic representation of an embodiment of a modular building of the present invention, showing a sewage system;

Figure 32 is a schematic representation of an embodiment of a modular building of the present invention showing an air conditioning system;

Figure 33 shows a diagrammatic layout of a modular office block building; and

Figure 34 shows a diagrammatic layout of a modular building forming a factory with offices.

Referring now to the drawings, figure 1 shows an exemplary modular building structure comprising a plurality of cabin modules 1 interconnected by corridors 2. The cabin modules 1 are designed to be furnished and used as, for example, offices or living quarters whereas the corridors 2 form passageways that, in addition to providing walkways between cabin modules 1, carry and distribute service supply lines to the cabin modules 1. The building shown has multiple storeys that are interconnected by a stairwell 3 in the foreground.

For the purposes of clarity end walls of the cabin modules 1 and all corridor walls are not shown. The only parts of the corridor shown are the floors and ceilings (which are combined on intermediate storeys).

The building structure is assembled from the cabin modules 1 and corridors 2 using the known honeycomb principle in which there is no overall super-structure and the integral strength of the structure is shared by each module both laterally and vertically so that should one module fail the load is taken up by adjacent modules. It will be seen from the drawing of figure 1 that the cabin modules 1 can be of different sizes although they are of the same basic construction. The cabin and corridor modules 1,2 can be designed in a range of standard sizes to allow for different building types and configurations to be assembled from factory produced units. The corridors 2 have the same basic construction as the cabin modules 1 but are adapted to have different end sections and different below floor or above ceiling structures. The modules 1 are interconnected in a fashion that makes them easy to replace or exchange so that the building can be updated or regenerated at any time.

The modular structure of the building is ideally suited to office buildings, hotels, schools, light industrial sites as well as residential buildings. It is not at this stage intended for buildings of a more significant size such as large factories, warehouses, stadiums and theatres etc.

The present invention is concerned with the structure and method of construction of the building structure, cabin modules 1 and the interconnecting corridors 2 and the manner in which the modules are fastened together.

The structure of each cabin module 1 is shown in detail in figure 2 and comprises a tetragonal box assembly comprising top, bottom and side walls 4,5,6 and open ends 7. The module 1 may be constructed in a range of different heights, lengths and widths. The walls 4,5,6 of the module comprise interior lining panels 8 that provide the central strength around which the remaining assembly is constructed, outer cladding panels 9 of metal and an intermediate foam or other material in-fill layer 10. Supporting framework 11 is provided at the corner intersections of the interior lining panels 8 and between the outer cladding panels 9 and the interior lining

panels 8 as described below. End frames (not shown) connect to the edges of the floor cladding panels 9 at each open end of the cabin module 1 and provide an interface for connection to other modules or corridors. These are described in detail below with reference to figures 14 and 15.

The interior lining panels 8 (shown in figure 3) are manufactured from, for example, plywood which provides strength combined with lightness. Moreover, plywood reduces the tendency of condensation to form; provides for improved thermal insulation and protection from cold bridges; is hard wearing; is practical for decorating, repairing and accommodating fixings for service equipment, decorative features, suspended ceilings and floors; and is less resonant and corrosive than alternative panel materials. Each lining panel 8 may be cut to provide apertures 12 for windows doors, service supplies or multi-purpose fixing points etc. as shown in figures 4 and 4a. The unexposed side of each lining panel 8 has a plurality of equi-spaced rebates 13 adjacent its side edges in order to receive corner joining members (described later) and adjacent its end edges (at 14) to accommodate end frame members (described below). Larger oval shaped rebates 15 are provided inboard of the other rebates 13,14 for receiving pads of a super-structure frame as described later.

The interior lining panels 8 are held together in a box form at their adjacent corners by a corner joining clamping assembly that is constructed from elongate extruded metal sections. The clamping assembly comprises an outer clamping member 16 that is generally L-shaped in cross-section (shown in figure 5), has a ridge 17 at its interior corner and raised feet 18 adjacent its interior edges that are complementary to the rebates 13 in the interior lining panel 8, and an inner clamping member 19 (shown in figure 6) that has an inner arcuate surface 20 and an outer surface 21 comprising three flat surfaces 22,23,24 a first and second 22, 24 of which are at right angles to each other and are separated by an intermediate third surface 23.

The outer clamping member 16 is located over each outside corner of the box defined by the interior lining panels 8. The raised feet 18 of the outer clamping member 16 engage in the rebates 13 of adjacent interior lining panels 8 and the ridge 17 projects into a clearance between the two panels 8. The inner clamping member 19

sits in the interior corners of the box and is fixed to the outer corner member 16 by bolts 25 that pass through apertures machined in the inner clamping member 21 and engage in a blind threaded bore 26 of the ridge 17. Once assembled, the first and second flat surfaces 22, 24 of the inner clamping member 19 abut the walls of interior lining panels 8 and the third surface 23 abuts the ridge 17 of the outer clamping member 16 so that the lining panels 8 are clamped together as is shown in figure 7. The strength of this clamping arrangement is crucial to the reduction of racking in the overall module structure. The inner clamping member 19 serves to stiffen the change in plane at each corner of the box structure.

The corners of the box assembly defined by the interior lining panels 8 of each cabin module 1 are further strengthened by corner brackets 27 (one of which is shown in figure 8) which are positioned at spaced intervals along the length of the cabin module 1. The corner bracket 27 is generally L-shaped and comprises a core section 28 cast in nylon plastic which is laminated with side plates 29 of sheet aluminium or steel. The interior corner of the bracket 27 is recessed slightly (as indicated at 30) to receive the outer member 16 of the corner joining clamping assembly. Bolt hole fixings 31 are provided through the side plates 29 and the core section 28 as shown. The bracket 27 is bolted to the outer clamping member 16 of the corner joining clamping assembly described above and also through the interior lining panels 8 as is shown in figure 9. The bracket provides electrolytic insulation between steel and aluminium depending on which metal is used for the outer cladding panels 9 and reduces the effect cold bridges in the walls of the cabin module 1.

The interior lining panels 8 are further supported by top hat frame assemblies that, in combination with the corner brackets 27 and longitudinal bearers (described later), provide lateral, vertical and diagonal strength to the cabin module 1. Each top hat frame member 32 is cut from zinc-coated sheet steel or aluminium into a flat plate (as shown in figure 10) using break press technology and is then pressed into the top hat configuration (shown in figure 11). The frame members are elongate three-sided members having a top wall 33 and side walls 34 that terminate in outwardly extending flanges 35 at their free ends. An end portion 36 of each frame member 32 has an

arcuate corner 37 and the region adjacent the interior of the corner is cut away (as indicated at 38) to receive a corner bracket 27 when assembled. Two such frame members 32 are interconnected by similar frame members 32a such that the corners 37 overlap and are connected together to form a closed rectangular frame assembly (see figure 13) that is fixed to the cabin module 1 at regular intervals along its length (as shown in figure 12). The frame members 32, 32a of each assembly 39 extend vertically along the exterior of the side walls 6 of the cabin module 1 and horizontally along the width of the top and bottom walls 4,5. The flanges 35 have fixing apertures 40 by which the frame assembly 39 is screwed to the outside of the interior lining panels 8. Glue may also be used for additional strength in the connection. The side walls 34 of the top hat frames 32 are secured together in the region of the corner brackets 27 by means of bolts 41 as shown in figure 18 (described later). The interior lining panels 8 serve to close the open face of the top hat frame assembly 39 and give it the strength properties of a four-sided box section structure.

At a later stage in the construction process the top hat frame assemblies 39 are filled inside and outside with pressurised polystyrene or other mineral in-fill for additional strength.

The edges of the interior lining panels 8 at each open end of the cabin modules 1 are fitted with end frame assemblies 42 to which end walls or other modules (not shown) may be fitted at a later stage. These end frame assemblies 42 are shown in figures 14 and 15.

Each end frame assembly 42 comprises three frame members: a main frame member 43; an inner frame member 44; and a support plate 45. Each of these members is formed from elongate metal extrusions. The main frame member 43 is generally channel-shaped comprising a main web 46 and two spaced subordinate webs 47, 48 that are integrally connected thereto at right angles. An upper surface of the main frame member defines a channel 49 which is used to drain water. The water can be passed between modules 1 by bridge members (not shown) and is eventually directed to ground. A first of the subordinate webs 47 terminates in a lip 50 that extends parallel to the main web 46 in a direction away from a second of the

subordinate webs 48 and has a ledge 51 designed to receive an edge of the support plate 45. The second subordinate web 48 has a plurality of projecting ridges 52 adjacent its free end, the ridges 52 being complementary to the rebates 14 in the interior lining panels 8. One end of the main web 46 extends slightly beyond the second subordinate web 48 so as to define a shoulder 53. The channel is closed by the support plate 45 that is bolted to the ledge 51 and the edge of the second subordinate web 48.

The inner frame member 44 is in the form of an elongate plate with lateral shoulders 54, 55 that extend in opposite directions, one at each elongate edge. During construction, the main frame member 43 and the inner frame member 44 are bolted together over an exposed end of the interior lining panel 8 such that an end portion of the panel 8 is sandwiched between the second subordinate web 48 of the main frame member 43 and the inner frame member 44. The shoulders 53, 54 on the main web 46 of the outer frame member 43 and at one edge of the inner frame member 44 abut one another and cover the exposed edge of the interior lining panel 8.

When the outer cladding 9 is fitted at a later stage (as described later) it is fixed to the lip 50 of the first subordinate web 47 by beading 56 as shown in the figures.

Further strength to the corners of the cabin module 1 is provided by longitudinal corner bearers 57, one of which is shown in figure 16. Each corner bearer 57 is an angled aluminium or steel extrusion that is generally L-shaped in cross section with a rounded external corner 58. The corner bearers 57 extend along the length of the cabin module 1 and are bolted at regular intervals to the corner brackets 27, the top hat frames 32 and the outer corner joining clamping members 16, as shown in figure 17. The longitudinal corner bearers 57 provide lateral support for the frame assemblies 11, longitudinal strength for the overall cabin structure and strengthen the corner joining clamping members 16, 19 against racking duress.

A completed corner assembly is shown in figure 18 with parts cut away for clarity.

For extra support and to provide lifting points to the cabin module 1 a super-structure assembly 60 is disposed between the interior lining panels 8 and the outer cladding panels 9 at the end of each cabin module 1. Each assembly 60, shown in figures 19 and 20) comprises a closed rectangular frame comprising four frame members. A vertical frame member 61 of oval cross section extends along the height of each side wall 6 whereas horizontal frame members in the form of T-shaped girders 62 extend across the width of the top and bottom walls 4, 5. The girders 61 are bolted at each end to the vertical frame members 61. Each of the frame members 61,62 has three oval shaped flat pads 62a that are spaced at regular intervals along its length, the pads 62a being complementary to the oval rebates 15 in the interior lining panels 8. The bottom end of each vertical frame member 61 is fitted with a telescoping jacking leg 63 having a terminal foot 64 that is designed not to extend beyond the edge of the cabin module 1. An adjustment mechanism be provided to adjust the length of each leg 63. It is contained within a removable housing received within a rectangular chamber 63a the superstructure frame.

When the cabin module 1 is fully assembled the oval pads 62a of each frame member 60,61 engage in the oval rebates 15 of the lining panels 8 and are glued in position. The rebates 15 may be provided with reinforcing nylon washers (not shown) for this purpose. The super-structure frame assembly 60 provides lifting points 65 (as indicated in figure 20) at the top and bottom corners to enable transportation of the cabin module 1. The weight of the cabin module 1 whether it is ground supported or being lifted is thus transferred through the integral strength of the interior lining panels 8. The super-structure assembly 60 also provides additional vertical, diagonal and lateral strength. It is fire insulated so that it provides for structural support in the event of a fire.

Each cabin module 1 is fitted with an internal suspended ceiling and floor 70, 71 (see figures 19 and 25) which are optionally connected to the super-structure frame assembly 60. Enclosed cavities 72, 73 are defined between the top interior lining panel 8 and the ceiling 70 and the bottom lining panel 8 and the floor 71 and accommodate service supplies, ventilation equipment, concealed lighting and other

ancillary equipment. The cavities 72, 73 may also conceal access points to the adjustment mechanism for the jacking legs 63 and other attachment points. For applications where the floor 71 is heavily loaded (e.g. with machinery) additional support may be provided in the floor or ceiling cavities.

The cabin module construction is completed by applying the outer cladding panels 9 and in-fill material 10 so as to form a consolidated sandwich construction that provides significant strength to the structure. The outer cladding panel 9 has an inner skin of zinc coated sheet metal and a replaceable outer skin of plastic coated metal. The four cladding panels 9 are replaceable independently or they can be changed for decorative or practical reasons, or for environmental adaptability. It will be appreciated that this prolongs the serviceability of a cabin module 1.

The in-fill material 10 is non-combustible and thermally insulating to provide fire protection by containing the heat within the cabin module 1. The outer cladding panels may also be coated with fire-resistant coating. Further fire protection is provided in the form of a fire sprinkler fitted in the ceiling cavity 72 and a fire resistant coating applied to the inner lining panels 9. Each cabin module 1 can be fitted with the appropriate visual and/or audio fire and smoke alarms.

The longitudinal corner bearers 57 cover and secure the adjoining edges of the outer cladding panels 9 and provide lateral support to the connection points (described below). They also protect the cabin module from damage when being transported and provide stacking support during storage or transport. Each longitudinal corner bearer 57 can be adapted to provide additional fixing points for foundations.

Each cabin module 1 has a plurality of connection points 80 (see figure 21) disposed at regular intervals at the top and bottom of all four walls 4, 5, 6 and at open ends of the cabin. The connection points 80 permit adjacent cabin modules 1 to be connected together by fixing arrangements that are secured from inside the floor or ceiling cavities 72, 73 and are defined by housings 81 (one shown in figure 23) disposed in the floor and ceiling cavities 72, 73. Each housing 81 has a circular access chamber 82 that is open to the interior of the cabin and an elongate bore extending radially from the access chamber 82 and out through a wall or an end frame (see

figure 24) of the cabin module 1. The fixing arrangement 84, shown in figure 22, comprises a double-headed fastening bolt 85 that carries a nylon plastic grommet 86. In use the grommet 86 and bolt 85 extend into aligned elongate bores 83 of the connection point housings 81 of adjacent cabin modules so as to connect two cabins together. Figure 21 shows the fixing arrangement 84 being used to connect together two cabin modules 1 side by side. The same arrangement is used to secure cabin modules 1 in vertical array, end-to-end or to connect corridor modules 2 to cabin modules 1. The open access chamber 82 of the housing 81 allows the fixing arrangement 84 to be easily inserted or removed.

The flexible nature of the grommet 86 permits adjacent modules to be coupled together without the requirement for their absolute alignment and without the fixing arrangement 84 becoming damaged or causing damage to the rest of the structure. The fixing arrangement 84 provides primarily horizontal fixing strength but also partial vertical strength. The same connection point and fixing arrangement may be used to secure ancillary modules such as fire escapes, verandas stairwells etc. to the cabin or corridor modules.

When cabin modules 1 are stacked on top of each other they are secured in a vertical direction by means of a half grommet fixing arrangement 84a that is fixed to the lifting points 65 of each superstructure assembly 60 as shown in figures 24a and c. The modules are lifted and placed on top of one another so that each half grommet fixing arrangement 84a is received in an aperture at the lower end of the superstructure assembly 60 of the cabin module 1 above. The half grommet fixings 84a are then bolted to the inside of the superstructure frame 61 under the floor cavity 73 of the cabin module 1 above as shown in figure 24e. When a cabin module 1 is standing on the ground it can be supported on the adjustable legs 63 or on half grommet fixings 84a secured or resting on to an appropriate foundation, to which the bottom of the superstructure assembly 60 may or may not be fixed.

A diagrammatic example of a gear-driven adjustment mechanism 63b for each leg 63 is shown in figure 24d. It is received in a removable box-shaped housing 63c that is located in chamber 63a of the superstructure frame member 61. The housing

63c and mechanism 63b are removed when the half grommet fixing arrangement shown in figure 24e is to be used.

Figure 24b illustrates that the half grommet is fixing 84a interchangeable with a lifting hook 84b that can be secured to lifting tackle when the cabin modules are moved.

Examples of a completed cabin module 1 with a suspended floor 71 and ceiling 72 are shown diagrammatically in figures 25 (with end wall removed for clarity to show suspended floor and ceiling) and 25a (end walls included). In both figures the end frame assemblies 42 are shown.

The cabin and corridor modules 1, 2 of the building structure may be supported and secured against the elements by one of many different foundation structures, none of which is depicted here. For example, for medium and long term applications metal rings attached to the jacking legs may be placed in the ground and filled with concrete. Alternatively for soft or snow covered ground skids may be secured to the super-structure assembly 60 with half grommet fixings. For swamp land, inland water and areas prone to flooding floatation rafts such as polystyrene blocks encapsulated in concrete surrounds are secured to the super structure assembly 60 with half grommet fixings. In environments where high wind pressure may be a problem the modules may be fitted with spreading bars that are secured to the super structure assembly with half grommet connectors. These spreading bars may be used in conjunction with other foundation structures if necessary.

For smaller building structure complexes the gap between the modules and ground may enclosed by boarding and filled with polystyrene. This foundation may be of particular use in areas liable to flooding and also provides for an aesthetic finish. Whilst polystyrene is appropriate for light weight and quick response applications other forms of mineral in-fill may be used for different applications. The type of in-fill and the pressure of this fill is selected accordingly.

Figure 26 shows part of a corridor module 2 connected to a transversely disposed cabin module 1. The corridor 2 is represented partially cut-away so as to expose service supplies that are carried to each cabin module 1. As mentioned earlier,

the structure of the corridor 2 is the same as that described in relation to the cabin modules 1. In the ceiling cavity 72 there is an air conditioning plant 90 including conduits as shown at 91 and an electrical supply installation 92 and corresponding wiring 93. A domestic water supply and waste disposal system is carried in the floor cavity 73 as indicated at 94. The corridor modules 2 define walkways that extend across adjacent corridor modules 2 or between corridor 2 and cabin modules 1. Gaps between connected modules are bridged around the walkway area by flexible bellows-type walkway couplings 95.

The floor and ceiling of each corridor module 2 has a support frame assembly, an example of a combined support frame assembly 100 for stacked modules being shown in figure 27 and 28. It comprises a plurality of transverse frames 101 that are equi-spaced along the length of the corridor 2 and are connected at each end to T-shaped corner brackets 102. The ends of each corner bracket 102 have shallow recesses 103 that are longitudinally aligned with corresponding recesses in neighbouring corner brackets 102 and receive a longitudinal bearer plate 104 that extends along the length of the corridor 2.

The support frame assembly 100 shown in figures 27 and 28 is designed to provide the interfacing floor and ceiling support structure for vertically adjacent corridor modules 2.

Two grommet connection point housings 81 are disposed in the spaces between adjacent frame assemblies 100. Floor and ceiling panels 70, 71 shown in figure 28 are secured to the support frame assembly 100 by conventional means.

Figures 28a and 28b show individual flat-pack ceiling and floor structures respectively. The support frame assemblies 100a, 100b are essentially half that used for the assembly 101 shown in figures 27 and 28.

A fully constructed and furbished corridor module is shown in figure 29 with the end shown open to expose the ceiling and floor cavities 72, 73. Figure 30 illustrates a semi-flat pack module in which the vertical walls of the module are separably connectable at the floor 72 and ceiling 71. Attached to the end of each corner bracket of the floor and ceiling support frame assembly 100 is an extrusion 96

that has apertures for bolts 96a that extend vertically between the extrusion and a casting 97 provided inside the top hat frame assembly 39 of each vertical wall. The walls are of the same height but may be of variable width to enable openings to be created and to accommodate different width modules or other accessories that are attached to the corridor (see figure 29).

An example of a waste disposal system for a building structure of the present invention is shown in figure 31. The system is shown in relation to a corridor comprising three axially joined corridor modules 2 and six cabin modules 1 connected on each side of the corridor 2. A service module 110 containing a suction pump and tank 111 is connected to an end of the corridor 2. Each corridor module 2 has a holding tank 112 in its floor cavity. Each tank 112 has flexible conduits 113 that are connected to a lavatory and wash area 114 of each cabin module 1 and adjacent holding tanks 112 are interconnected by a suction waste pipe 115. The figure also shows the flexible bellows coupling 95 between each corridor module 3 and between each cabin 1 and corridor module 2.

In figure 32, there is shown an exemplary air conditioning system depicted in relation to part of a building structure comprising a central corridor constructed from three axially connected corridor modules 2 and six cabin modules 1, three on each side of the corridor 2. At one end of the corridor 2 there is a service module 120 containing a central plant 121 that feeds a heat exchanger 122 in the immediately adjacent corridor module 2. Further heat exchangers 122 are located in each corridor module 2, each heat exchanger 122 being connected to that of the adjacent corridor module 2 and to further heat exchangers 123 situated in each adjacent cabin module 2. An exhaust heat pump 124, connected to the corridor heat exchanger 122, is located outside each corridor module 2. Besides the central air conditioning plant the service module 121 may also contain central alarm and security control systems, service repair and spare equipment, telephone transmission and reception equipment, television reception apparatus, a fresh water distribution manifold, and, in the case of remotely located building structures, electrical generators.

Using corridors of this type it is possible to provide accommodation for short term applications without the need to provide pathways, foundations or to conduct preliminary ground excavation for drains and service supply lines. The investment generally made in creating such facilities are therefore not lost when relocating the building structure. The arrangement also enables building complexes to be sited on sloping or undulating sites without the need for gravity waste disposal. Any noisy equipment is conveniently located in the corridors leaving the cabin modules free of noise, vibration and clutter. The air conditioning also provides protection from outside interference (which is particularly desirable in noisy, dusty environments) as well as reducing condensation.

The standard cabin or corridor modules may be adapted as necessary depending on how they are to be used. For example, the corridor rooves may be made in a double-glassed construction to provide a conservatory. Ancillary structures such as, for example, fire escapes, balconies, canopies and exterior walkways may be connected to the modules by the grommet fixing arrangements described above.

The modular nature of the corridor and cabin modules means that many different building layouts are possible. Examples are shown in figures 33 and 34. The former shows a layout an office block having a first corridor 130 with three office cabin modules 131 on one side and four cabin modules 132 on the other side designated for three smaller offices and a pantry. One end of the first corridor module 130 meets a transversely extending second corridor module 133 which is connected to four cabin modules 134 that are furbished as toilets, a reception area, and a service module with store.

In figure 34 there is shown an example layout for a factory with offices. A central corridor 140 comprising two modules interconnects a demonstration and show room 141 comprising two side-by-side cabin modules at one end and a workshop area 142 comprising five side-by-side cabin modules at the other end of the corridor 140. Cabin modules 143 of various sizes connect to the corridor on each side and are furbished as offices, lavatories, a service modules and a pantry. The workshop area 142 is connected to three cabin modules defining a delivery area 144.

Broadly speaking the on-site procedure for constructing a building of this type is as follows:

a) the service module is delivered to the site and placed in the correct location;

b) the foundations are laid down with access roads, car parking, boundary fences etc.;

c) the cabin modules and corridor modules are delivered and secured to the foundations and to each other; and

d) the mains service supplies are routed from the service module along the corridor floor and ceiling cavities through to the cabin modules and the building is tested for occupation.

The building structures of the present invention differ from previous prefabricated buildings in that they are manufactured in their entirety in modular format together with completed interiors. The buildings are comparatively lightweight, do not have an overall superstructure and require only limited foundations. In view of the modular structure the on-site construction is less complicated and more rapid that conventional buildings. The range of module sizes allows for all buildings to be assembled from factory produced units.

One of the main advantages is the considerable cost reduction for manufacturing buildings of this kind. A considerable quantity of variable applications can be constructed from comparatively few basic building blocks. The system provides factory finished interiors and internal services which are generally of a higher quality and cheaper to produce than those constructed on-site. The speed and simplicity with which the honeycomb structure building can be erected dramatically reduces the construction time and costs. In addition there is a significant reduction in pre-building costs such as those expended in employing architects, surveyors, site management etc.

The construction of the cabins is suitable for mass production giving both labour and materials cost advantages. The different sizes of module produced by using differing dimensions of the same product means and incorporating different end

sections that many different markets can be supplied without creating the need for different manufacturing processes.

Bare cabins (with the floor, ceiling and end sections fitted) can be delivered to special outfitters where they are furbished before being transported to the construction site.

Transportation of the modules is simplified as they are lightweight and strong enabling them to be placed and moved on a lightweight trailer rather than a heavy duty vehicle. The structure of the modules is such that they can be transported on their sides if necessary. The modules are also suitable for air transport to inaccessible locations or in military applications or circumstances where a quick response in required (e.g. emergencies such as natural disasters).

Once built, the building structure can later be modified, expanded or reconfigured to suit changing requirements relatively simply. In addition, the building structure can be relocated in whole or in part with ease.

Since the component modules are of standard design, the building structure lends itself well to simple computer modelling and virtual reality systems that enable layout planning. The simplicity would also enable the end user of the building to participate in the design of the building.

The modular nature of the building enables it to be enlarged or reduced in size as appropriate. This may have advantage for both the residential and commercial market. For example, first time residential buyers will be able to start with a small one bedroom house, expand the size of the building over time by adding extra modules as the family grows and reduce the size of the building by removing modules as the family size diminishes. The style of the house can be constructed to suit the owner's preferences. Similarly, in the commercial realm the size of the building can be varied throughout its life to reflect the growth or diminishing size of the business.

Similarly, disused modular buildings can be dismantled and removed so that ugly, dilapidated or vandalised buildings can be quickly removed. A minimum disturbance to land structure means that land can be returned to green site conditions after the buildings have been removed

Valuing property for sale or financing purposes is simplified in that the value of the property is no longer restricted by its location and design and can be easily assessed by the aggregate value of its component parts while the site is valued separately in terms of size and location.

The present invention provides for improved durability in prefabricated buildings of about 40 years with a higher standard of interiors and internal services as compared to the 15 years for existing structures.

CLAIMS

1. A modular building structure comprising a service module defining a plurality of connection nodes for connection to separate building modules, the service module containing apparatus for the supply and distribution of at least one mains service to the building modules, each building module being free-standing, pre-fitted for its intended use and connected to one of said connection nodes and to said supply of at least one mains service.

2. A modular building structure according to claim 1, wherein the service module is in the form of a corridor walkway linking the building modules.

3. A modular building structure according to claim 1 or 2, wherein the service module has floor and ceiling cavities in which the mains service supplies are routed.

4. A modular building structure according to any one of claims 1 to 3, wherein one building module is a dedicated plant room that feeds the mains supply service to the service module.

5. A modular building structure according to any preceding claim, wherein the service module is sectional so that it can be extended or shortened to provide more or less connection nodes as required.

6. A modular building structure according to any preceding claim wherein there is provided a plurality of service modules, some modules being disposed in a direction transverse to others.

7. A modular building structure according to any preceding claim, wherein the mains service is for waste disposal and each service module is provided with a holding tank that is connected to a lavatory or wash area of an adjacent building module.

8. A modular building structure according to claim 7, wherein holding tanks of adjacent sections of a service module are connected by a suction waste pipe.

9. A modular building structure according to any preceding claim, wherein the mains service supply is air conditioning and each service module is fitted with a heat exchanger and has an external pump for evacuation of warm air.

10. A modular building structure according to claim 9, wherein each building module also has its own heat exchanger that is connected to the pump and heat exchanger of an adjacent service module.

11. A modular building structure according to any preceding claim, wherein each adjoining pair of building modules or service modules has apparatus for connecting adjacent modules, the apparatus comprising a housing defining apertures that extend into the structure of each module and a flexible insert that is snugly received in each aperture and bridges the two modules, the flexible insert being supported on a fixing element that is secured to each of the modules.

12. A building module comprising an inner shell of planar walls connected at its corners by corner connection assemblies to define a box structure, an exterior framework assembly connected to the inner shell and the corner connection assemblies for supporting the box structure, an outer shell and a material in-fill disposed in a cavity defined between the inner and outer shell, the exterior framework assembly being disposed principally between the inner and outer shells.

13. A building module according to claim 12, wherein the corner connection assemblies comprise first and second clamping members, the first clamping member being disposed on the interior corner of the box structure and the second clamping member being disposed on the exterior corner of the box structure, the clamping members being connected together so as to clamp the adjacent planar walls together.

14. A building module according to claim 13, wherein the corner clamping members have protruding elements that engage in recesses in the planar walls of the inner shell.

15. A building module according to claim 12, 13 or 14, wherein the exterior framework assembly comprises a plurality of frames that are spaced at intervals along the length of the module.

16. A building module according to claim 15, wherein each frame comprises a four-sided assembly, each frame member of the assembly being connected to the exterior of a wall of the inner shell.

17. A building module according to claim 16, wherein each frame member is of top-hat configuration having three sides that define a channel which, when assembled, is closed by the respective wall of the inner shell.

18. A building module according to claim 17, wherein the closed channel is filled with support material.

19. A building module according to any one of claims 12 to 18, wherein the corner connection assemblies further comprise at least one corner bracket that is connected to the exterior of the second corner clamping member.

20 A building module according any one of claims 12 to 19, wherein there is provided an end frame disposed over exposed end edges of the box section.

21. A building module according to claim 20, wherein the end frame comprises first and second portions that form a sandwich with a respective wall of the inner shell by receiving the end of the wall and clamping it therebetween.

22. A building module according to claim 20 or 21, wherein the end frame provides attachment points for the outer shell and provides water drainage means.

23. A building module according to any one of claims 12 to 22, wherein the outer shell comprises a plurality of planar cladding panels.

24. A building module according to any one of claims 12 to 23, wherein each corner of the module is fitted with a longitudinal bearer plate that extends along the length of the module and is connected to the exterior framework and the corner connection assemblies to provide lateral support therefor.

25. A building module according to claim 24, wherein the longitudinal bearer plates interconnect adjacent panels of the outer shell.

26. A building module according to any one claims 12 to 25, wherein there is provided at least one super-structure frame assembly that is connected to the inner shell and provides lifting points for the module.

27. A building module according to claim 26, wherein the super-structure frame assembly also comprises jacking legs by which the module may be raised or lowered relative to the ground.

28. A building module according to claim 26, wherein the super-structure frame assembly also comprises a fixing assembly for fixing the module to a vertically adjacent module.

29. A building module according to claim 28, wherein the fixing assembly comprises a flexible insert for receipt in a housing of an adjacent module.

30. A building module according to claim 26 or 27, wherein the super-structure frame assembly has pads that engage in recesses on the exterior walls of the inner shell.

31. A building module according to any one of claims 12 to 30, wherein each module is provided with a suspended floor and ceiling so as to define floor and ceiling cavities with upper and lower walls of the inner shell.

32. A building module according to claim 31, wherein the cavities house mains service supply apparatus.

33. A building module according to claim 32, wherein the module is mounted on a foundation of polystyrene.

34. A building module according to any preceding claim wherein there are provided removable floor and ceiling support frame assemblies that permit the module to be stored or transported in a semi-flat pack configuration.

35. A method for constructing a modular building structure, the method comprising the steps of: preparing a site on which the building structure is to be located; installing a service module on the prepared site, the service module defining a plurality of connection nodes for connection to separate building modules; installing at least one mains supply service to the service module; connecting at least one pre-

constructed building module to a connection node and connecting it to the mains supply service of the service module.

36. A method according to claim 35, comprising further steps of filling a clearance between the module and ground with a foundation of polystyrene.

37. Apparatus for connecting adjacent building modules, the apparatus comprising a housing defining apertures that extend into the structure of each building module and a flexible insert that is received in each aperture and bridges the two building modules, the flexible insert being supported on a fixing element that is secured to each of the building modules.

38. Apparatus according to claim 37, wherein the housing further comprises an access chamber that is open to the inside of the building module so as to facilitate insertion of the fixing element and flexible insert.

39. Apparatus according to claim 37 or 38, wherein the apparatus for connecting adjacent building modules is disposed in a floor or ceiling cavity of the building module.

40. Apparatus according to any one of claims 37 to 39, wherein the insert is a grommet.

41. A modular building structure substantially as hereinbefore described with reference to the accompanying drawings.

42. A building module substantially as hereinbefore described with reference to the accompanying drawings.

43. A method for constructing a modular building structure substantially as hereinbefore described with reference to the accompanying drawings.

44. Apparatus for connecting adjacent building modules substantially as hereinbefore described with reference to the accompanying drawings.

ABSTRACT

MODULAR BUILDINGS

A modular building structure comprises a service corridor to which are connected separate cabin modules that form accommodation or offices etc. The service module contains apparatus for the supply and distribution of mains services such as water, electricity , waste disposal and air conditioning to the building modules. The modules are connected to the corridor and to said mains supply services. Each of the cabin modules is free-standing, pre-fitted for its intended use and comprises an inner shell connected at its corners by corner connection assemblies to define a box structure. An exterior framework assembly is connected to the inner shell and the corner connection assemblies for supporting the box structure. The module has an outer cladding shell and a material in-fill disposed in a cavity defined between the inner and outer shell, the exterior framework assembly being disposed principally between the inner and outer shells. The module may have separable floor and ceiling support sections to allow it to be transported or stored in a semi-flat pack configuration.

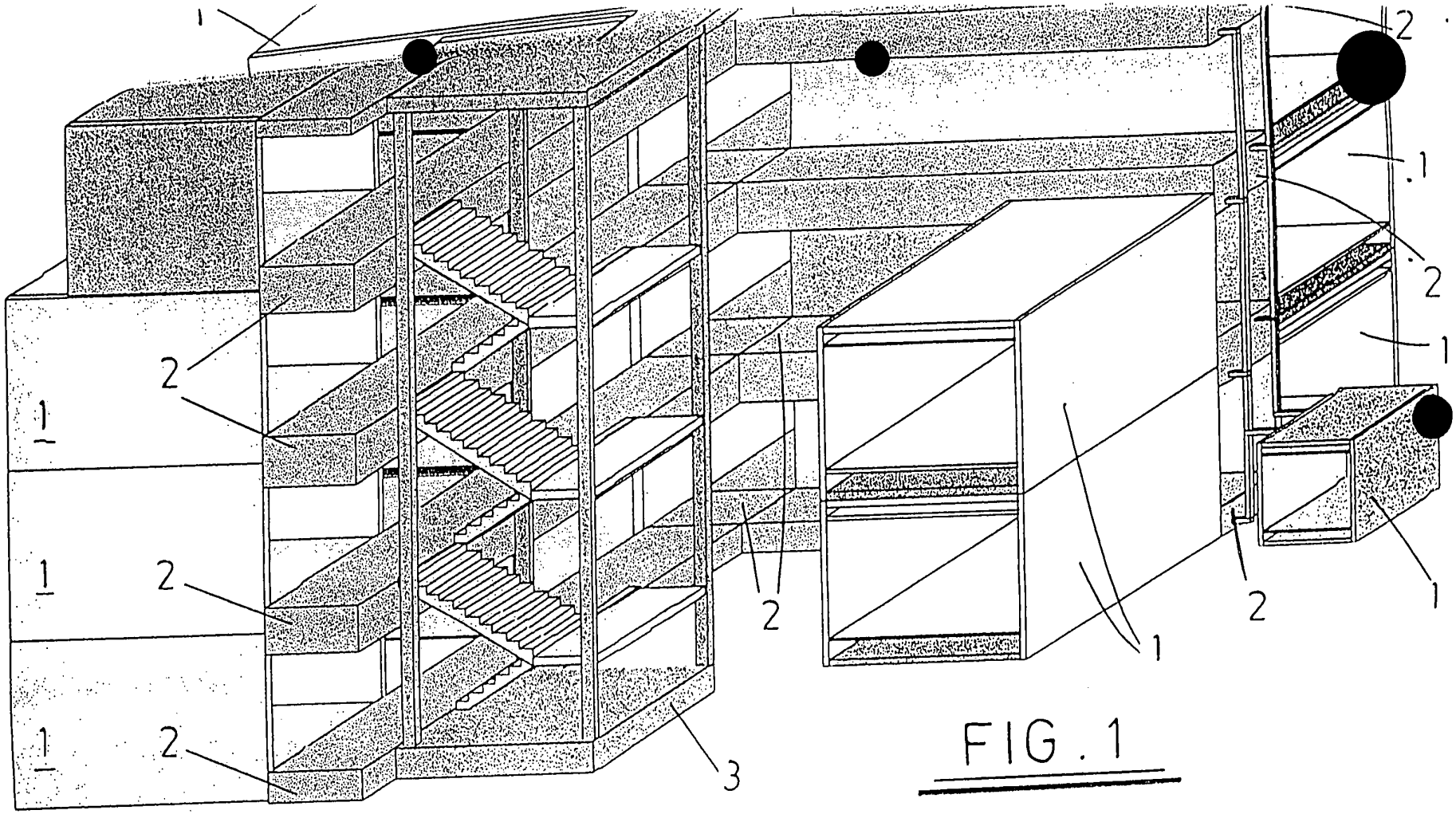

FIG. 1

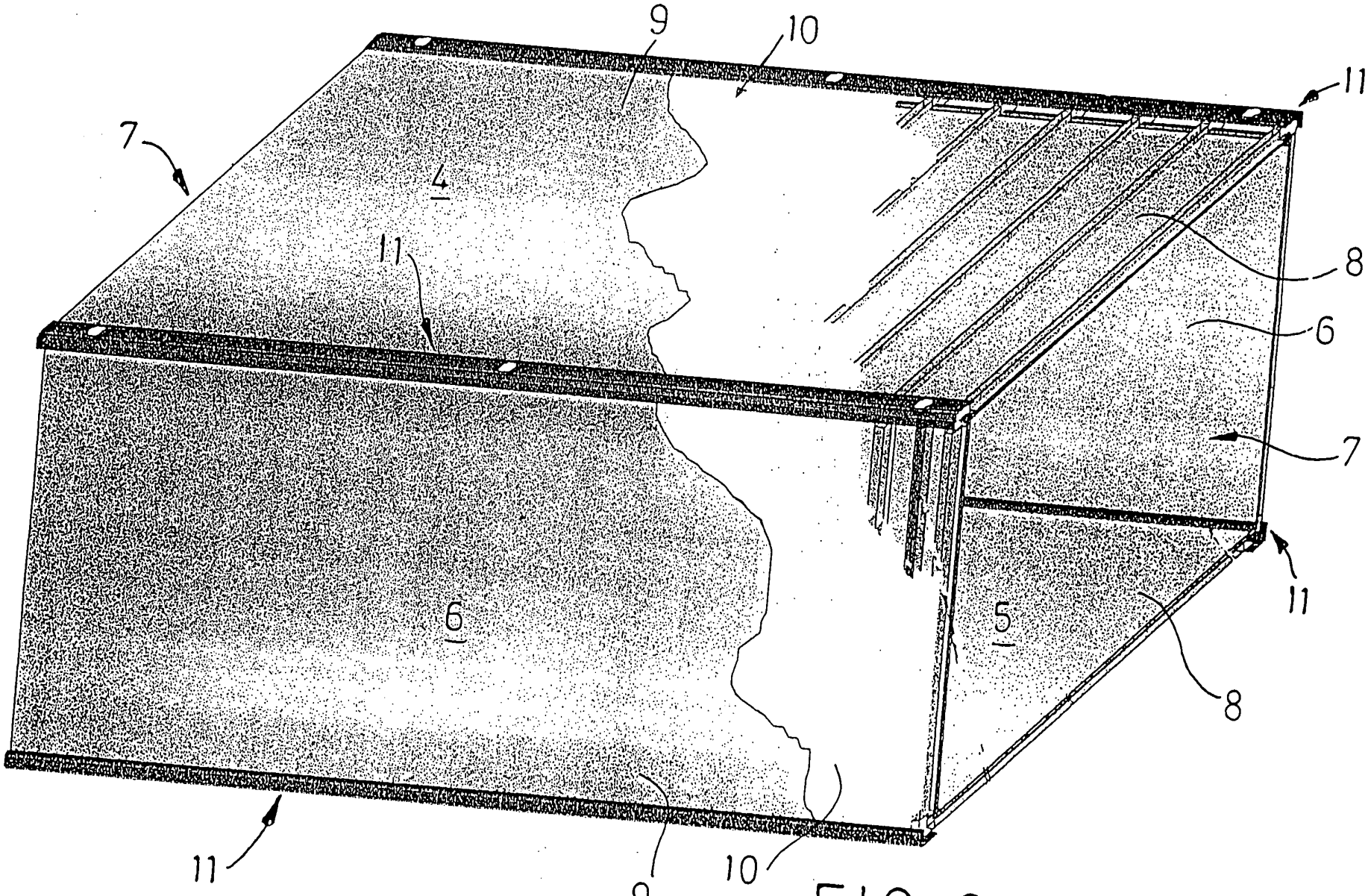

FIG. 2

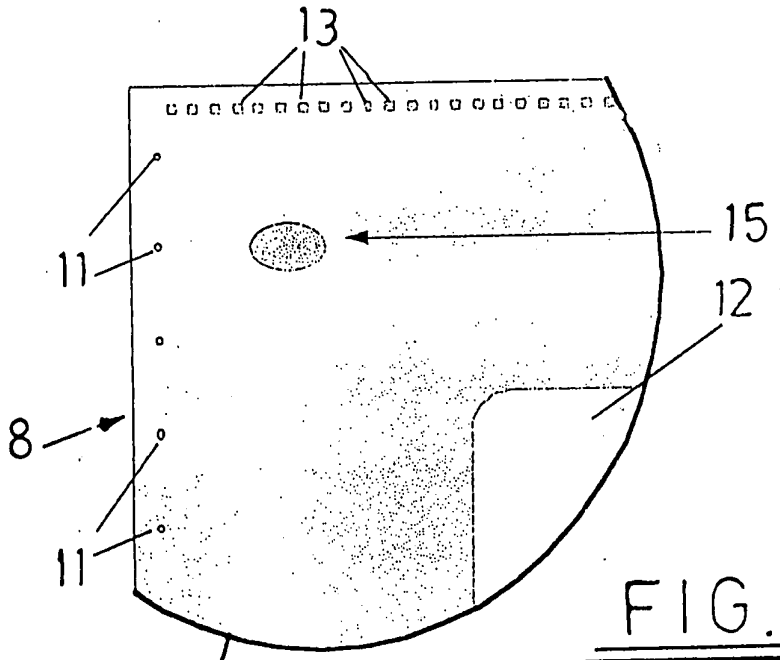

FIG. 4a

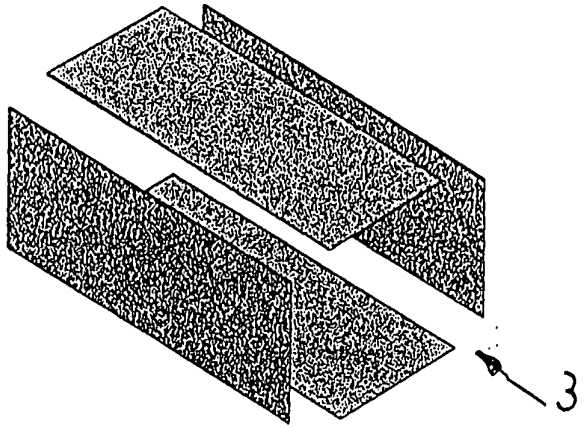

FIG. 3

Reverse side (Inside the wall)

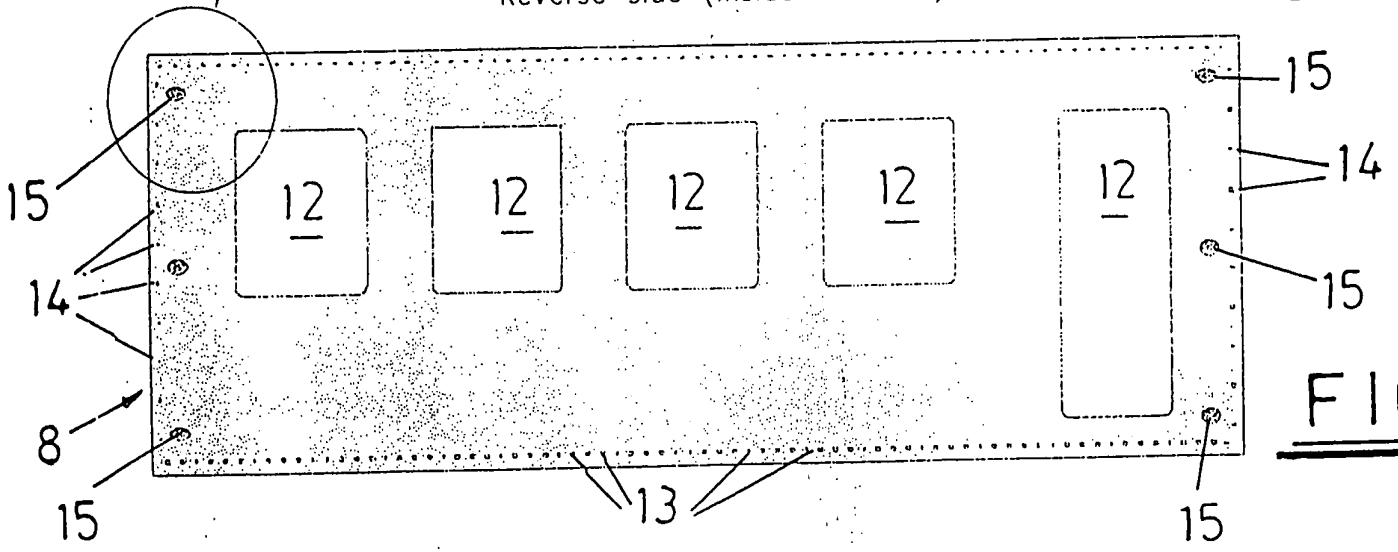

FIG. 4

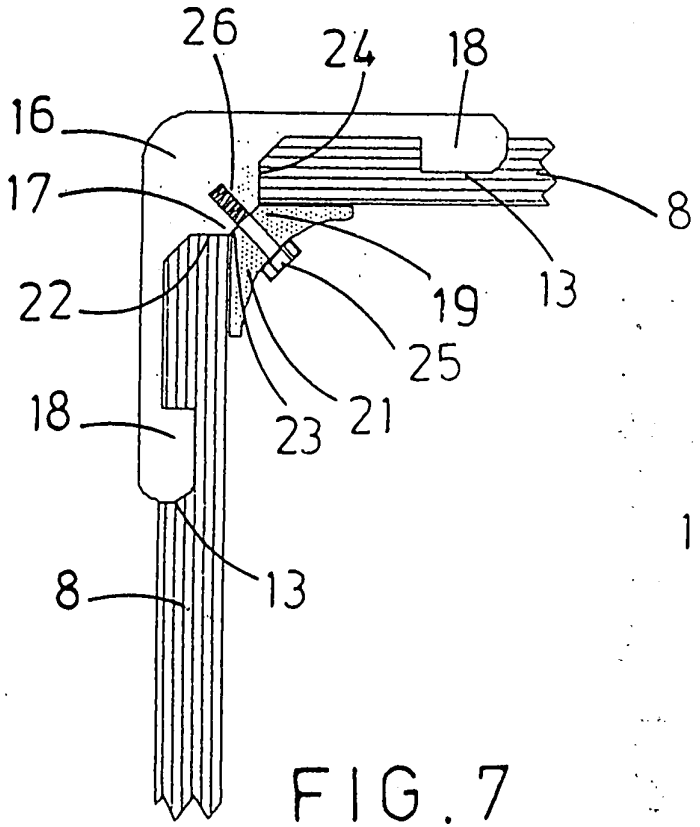

FIG. 7

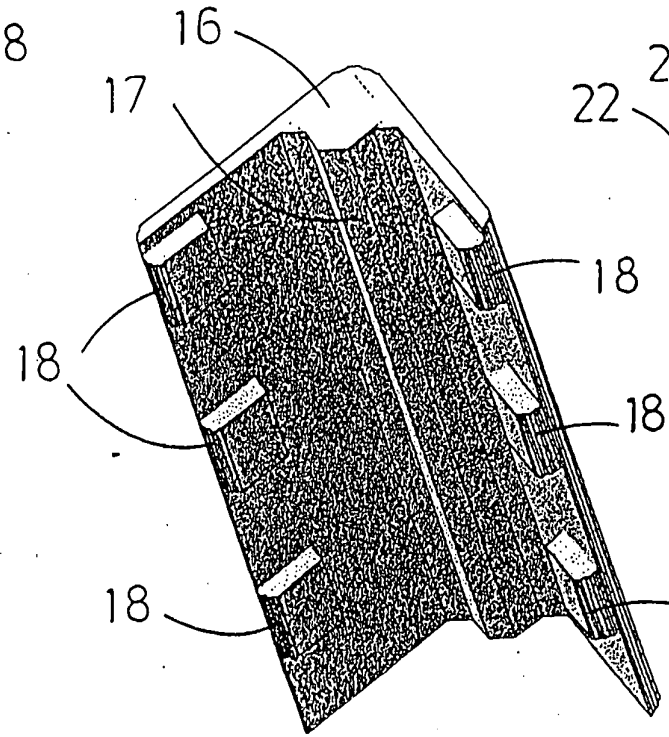

FIG. 5

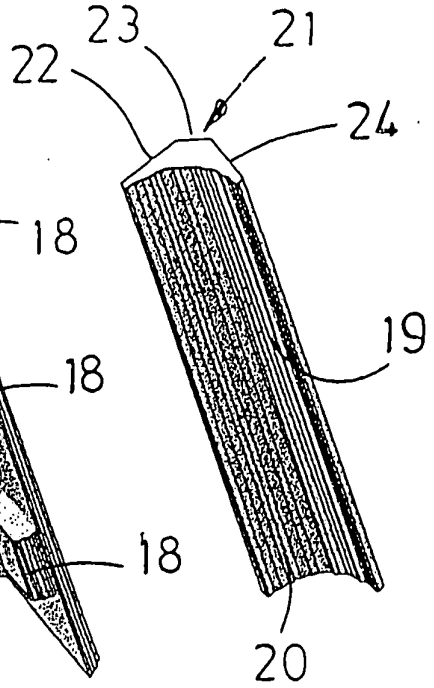

FIG. 6

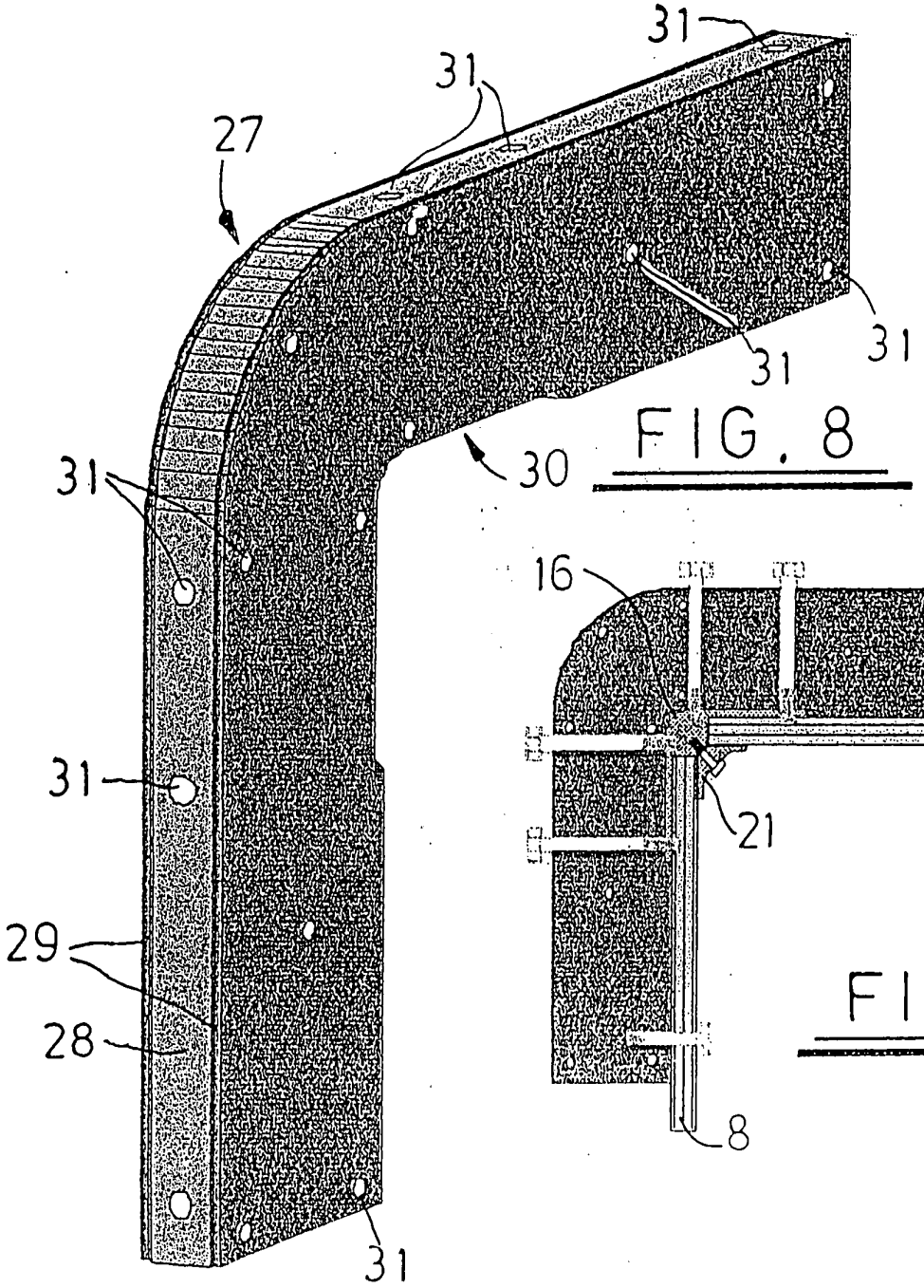

FIG. 8

FIG. 9

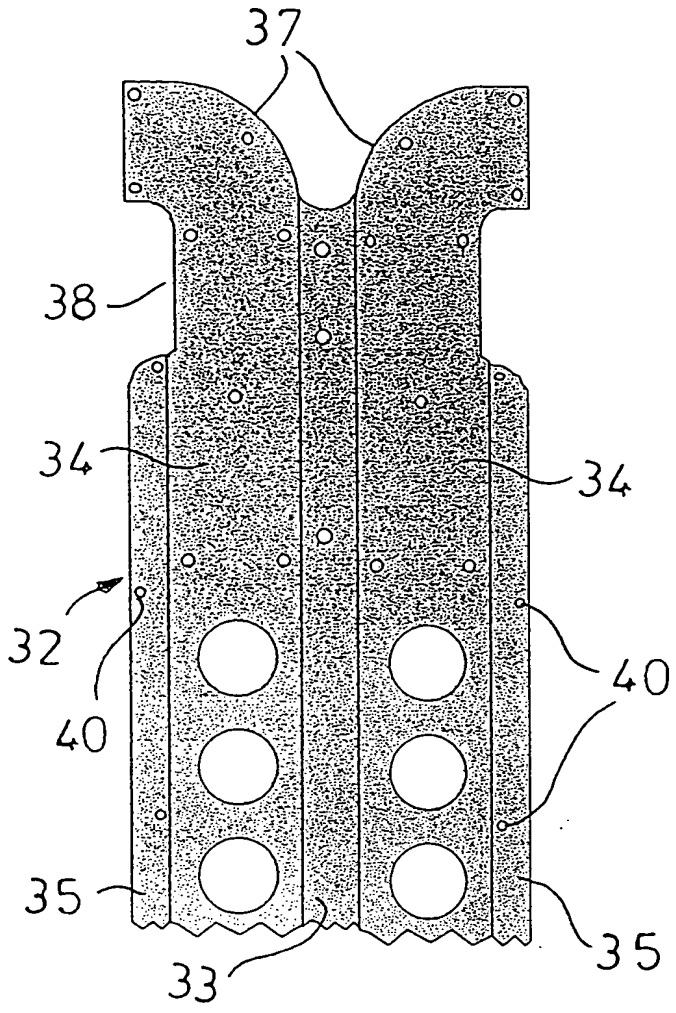
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FIG. 10

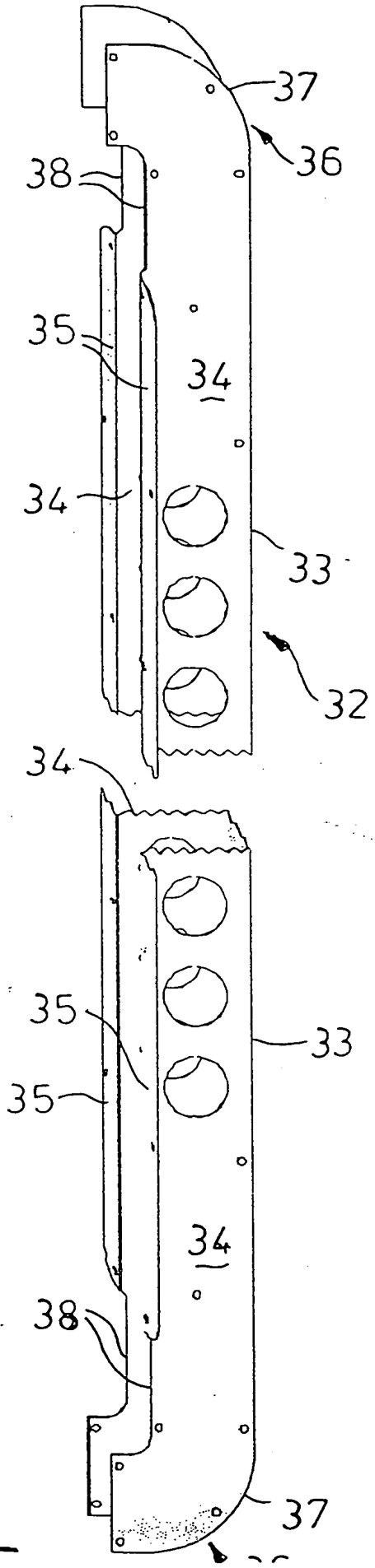
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FIG. 11

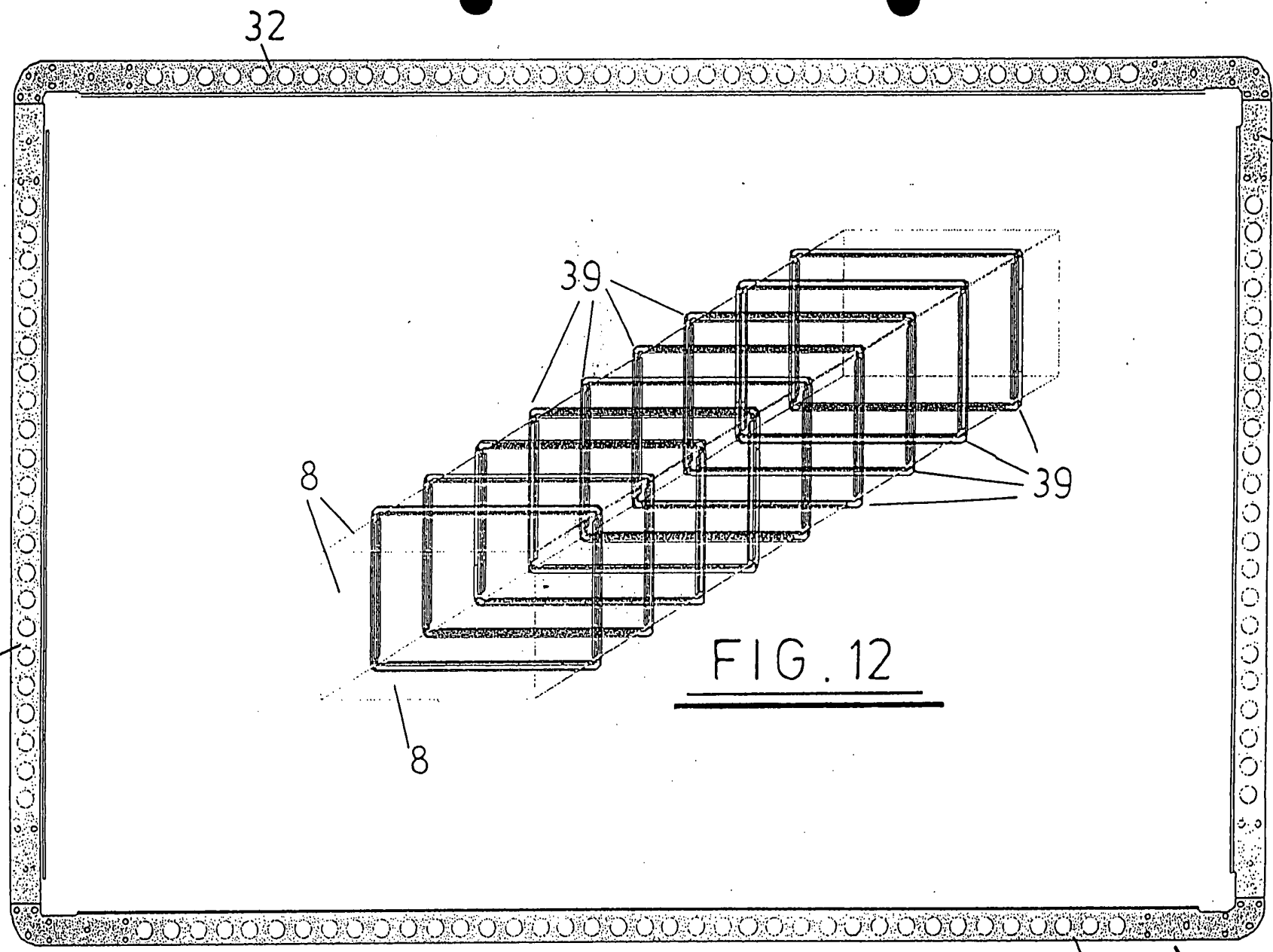

FIG. 12

FIG. 13

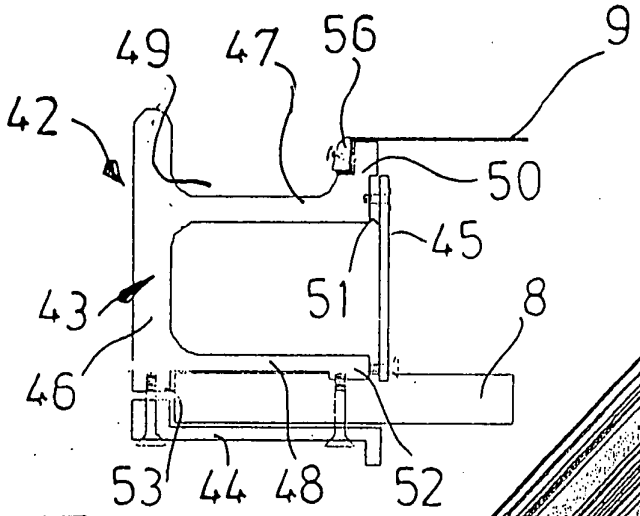
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FIG. 15

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FIG. 14

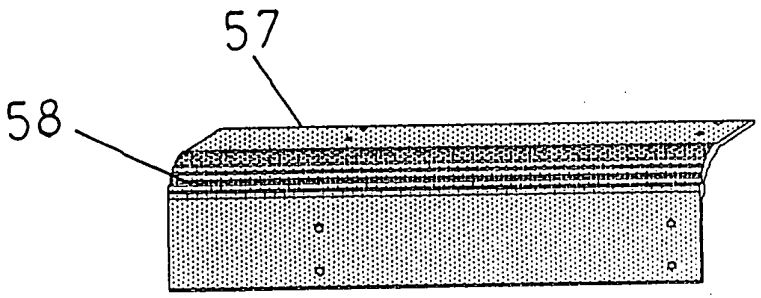

FIG. 16

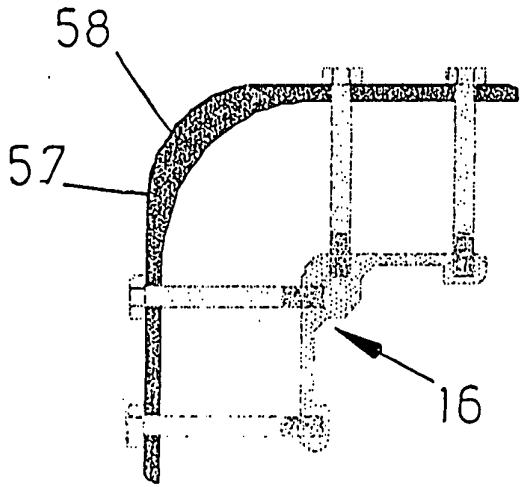

FIG. 17

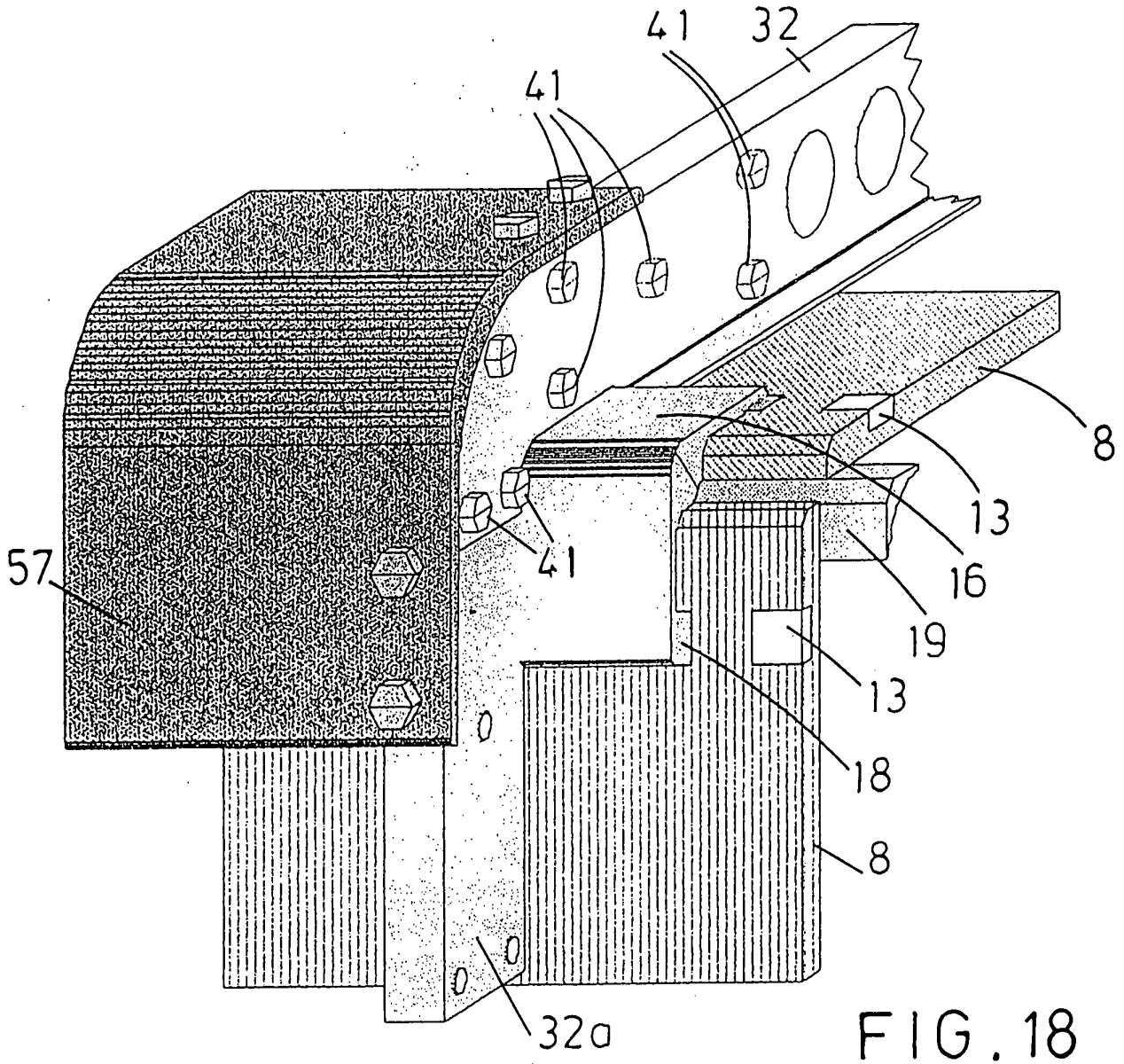

FIG. 18

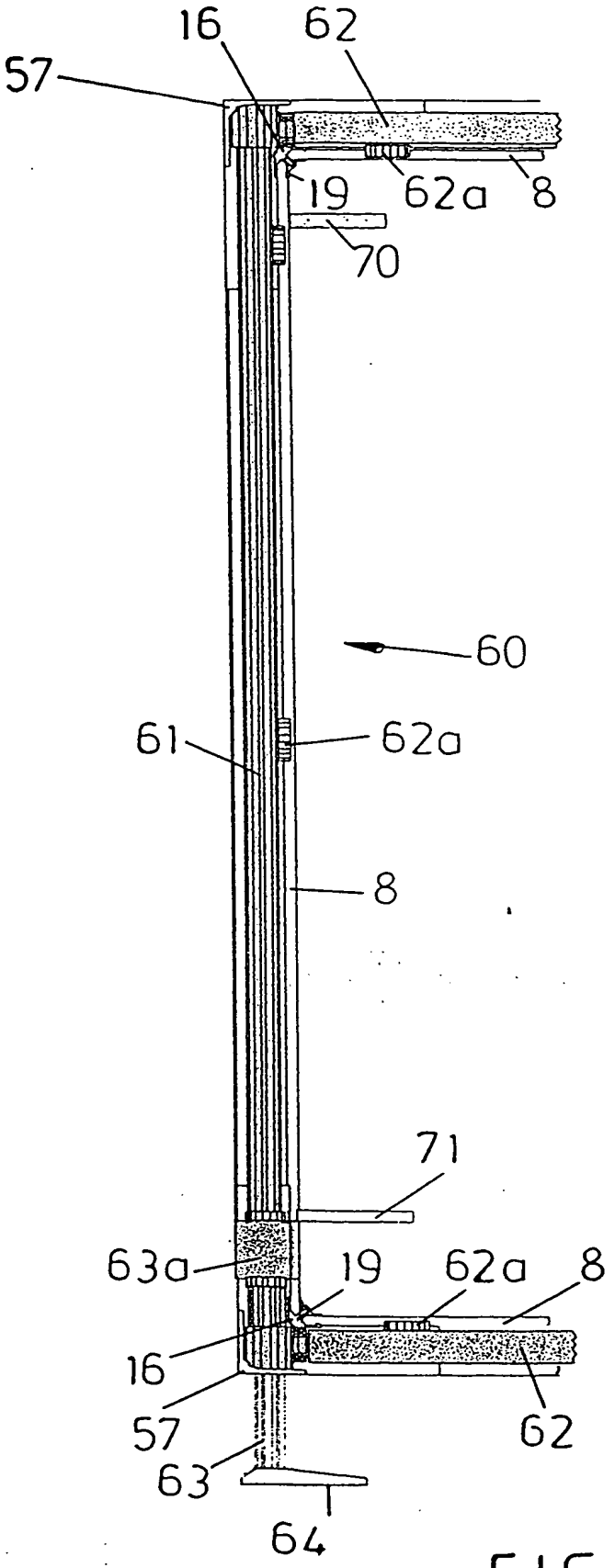

FIG. 19

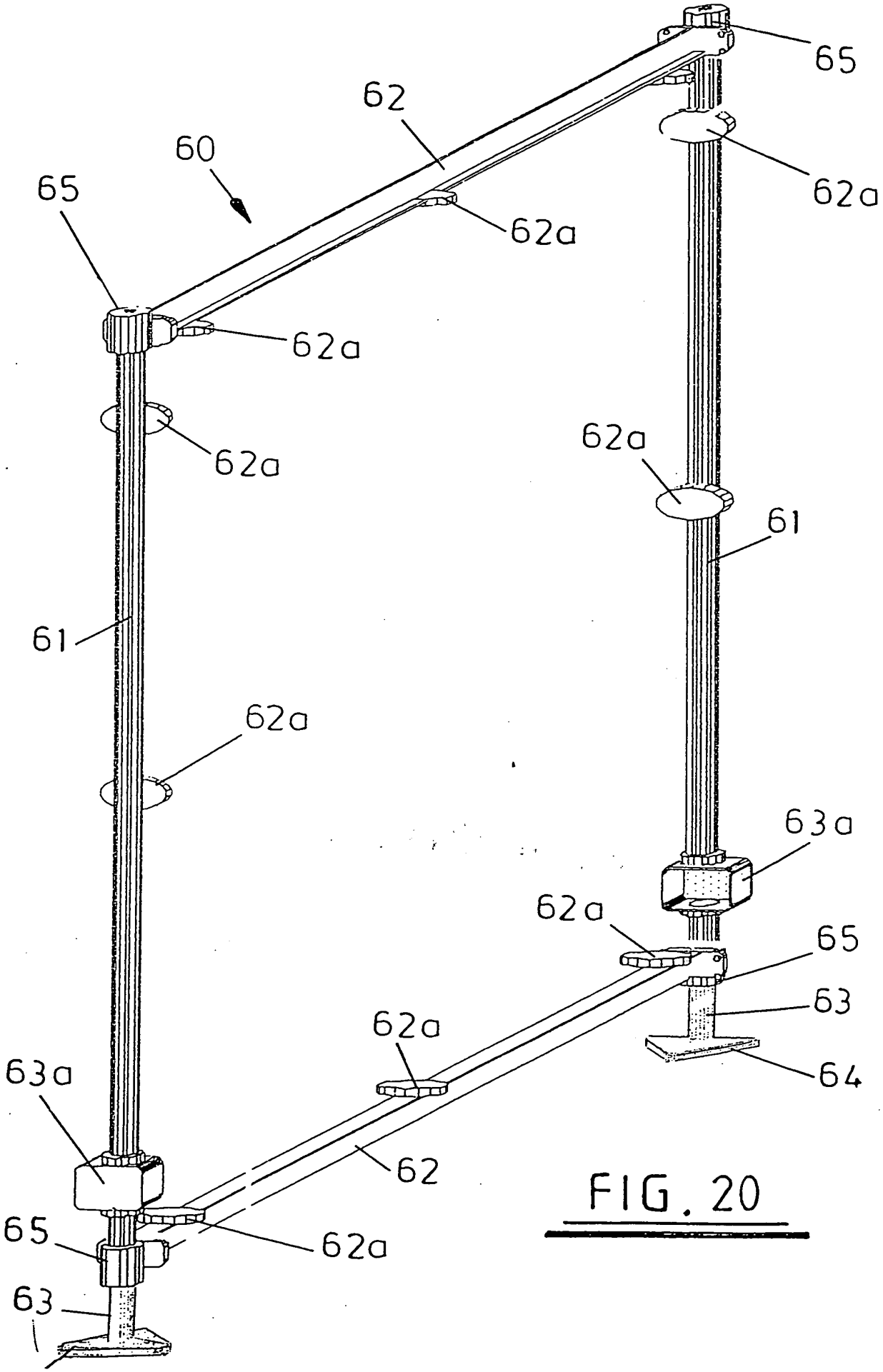
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FIG. 20

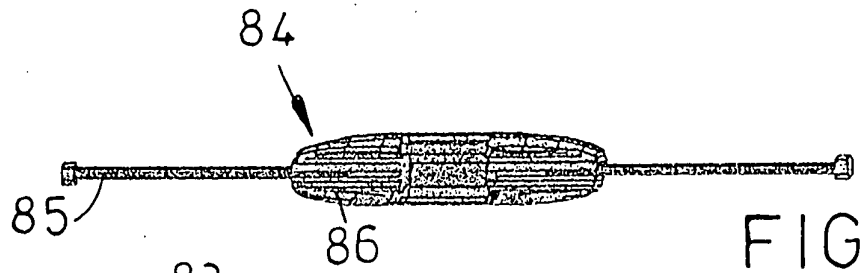

FIG. 22

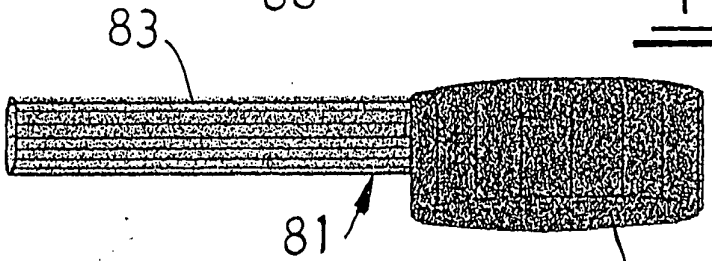

FIG. 23

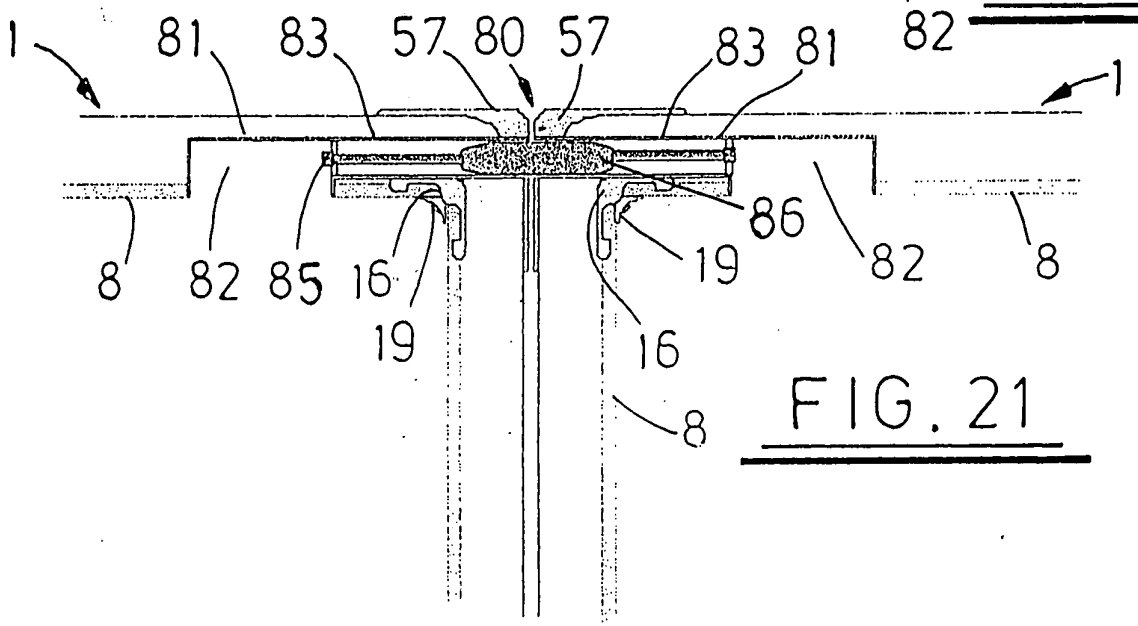

FIG. 21

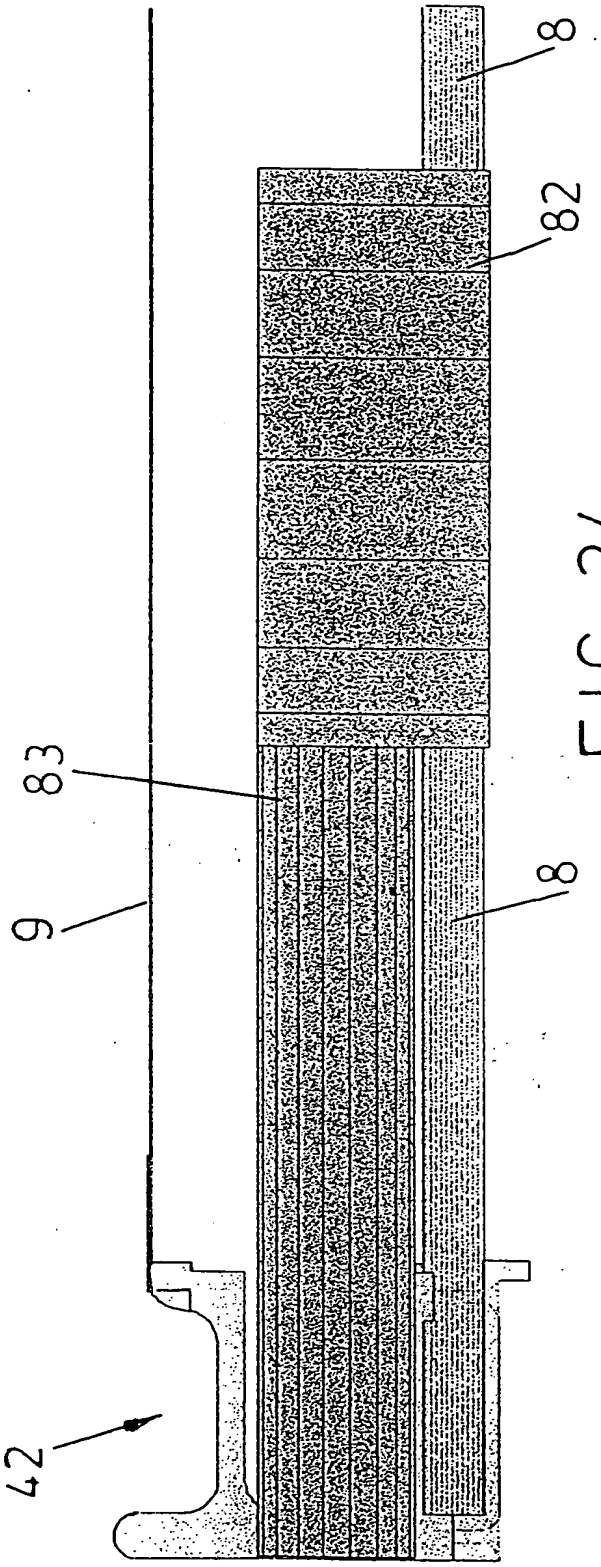

FIG. 24

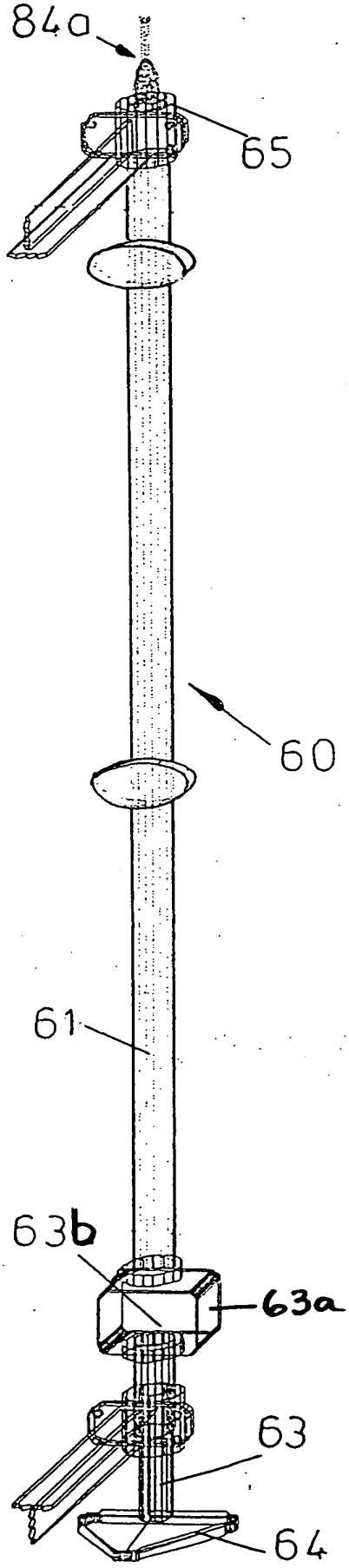

FIG. 24a

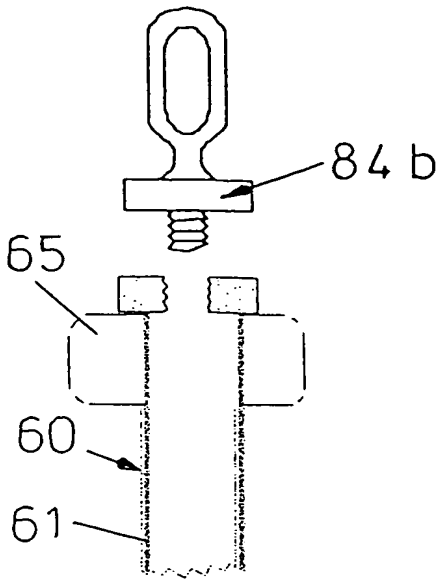

FIG. 24b

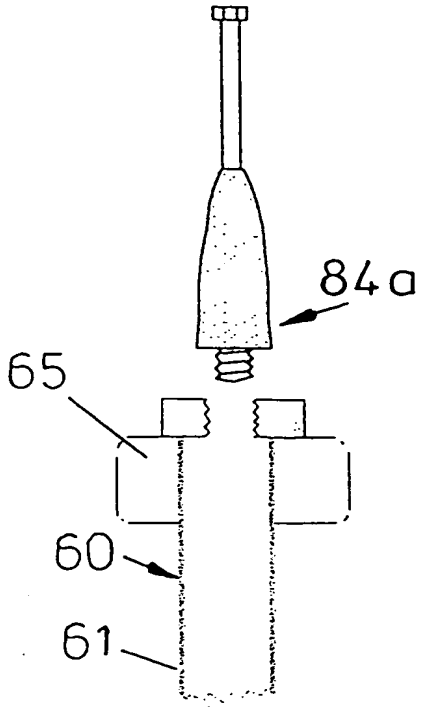

FIG. 24c

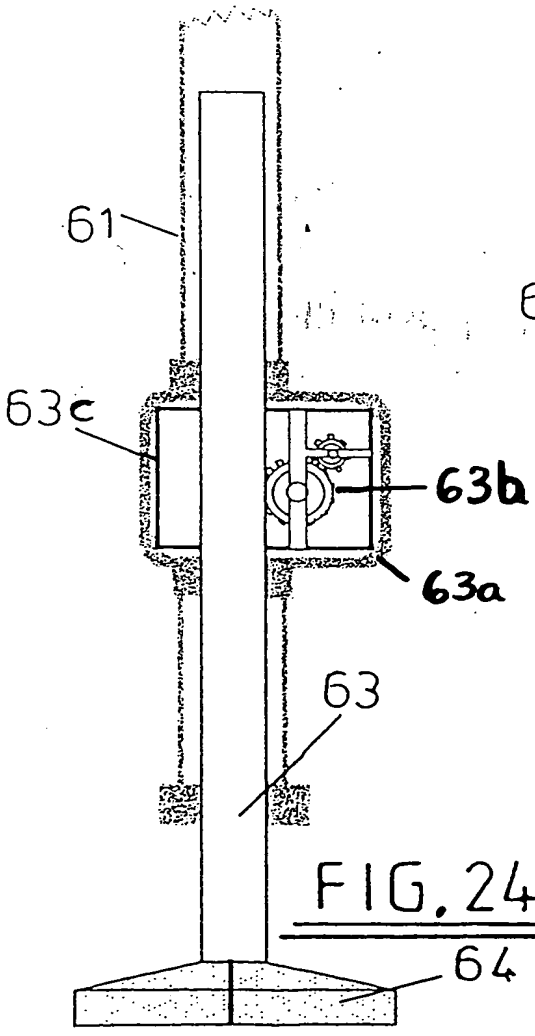

FIG. 24d

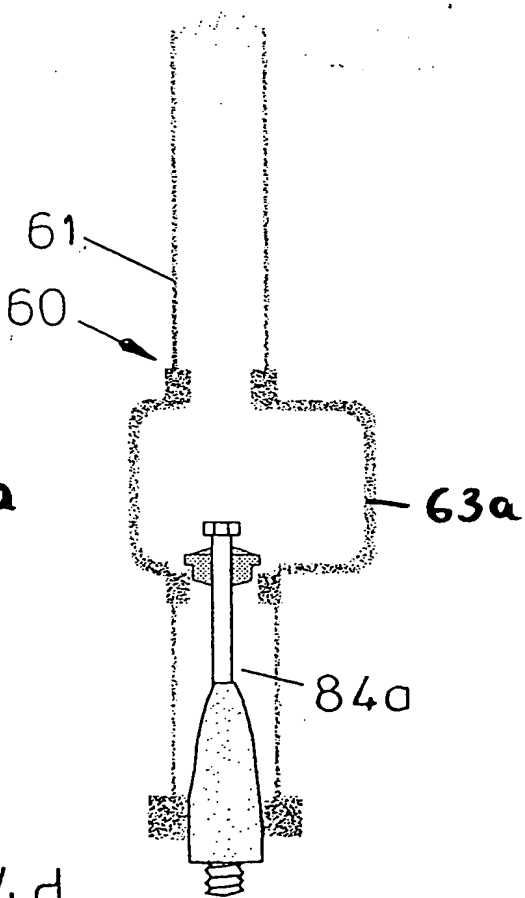

FIG. 24e

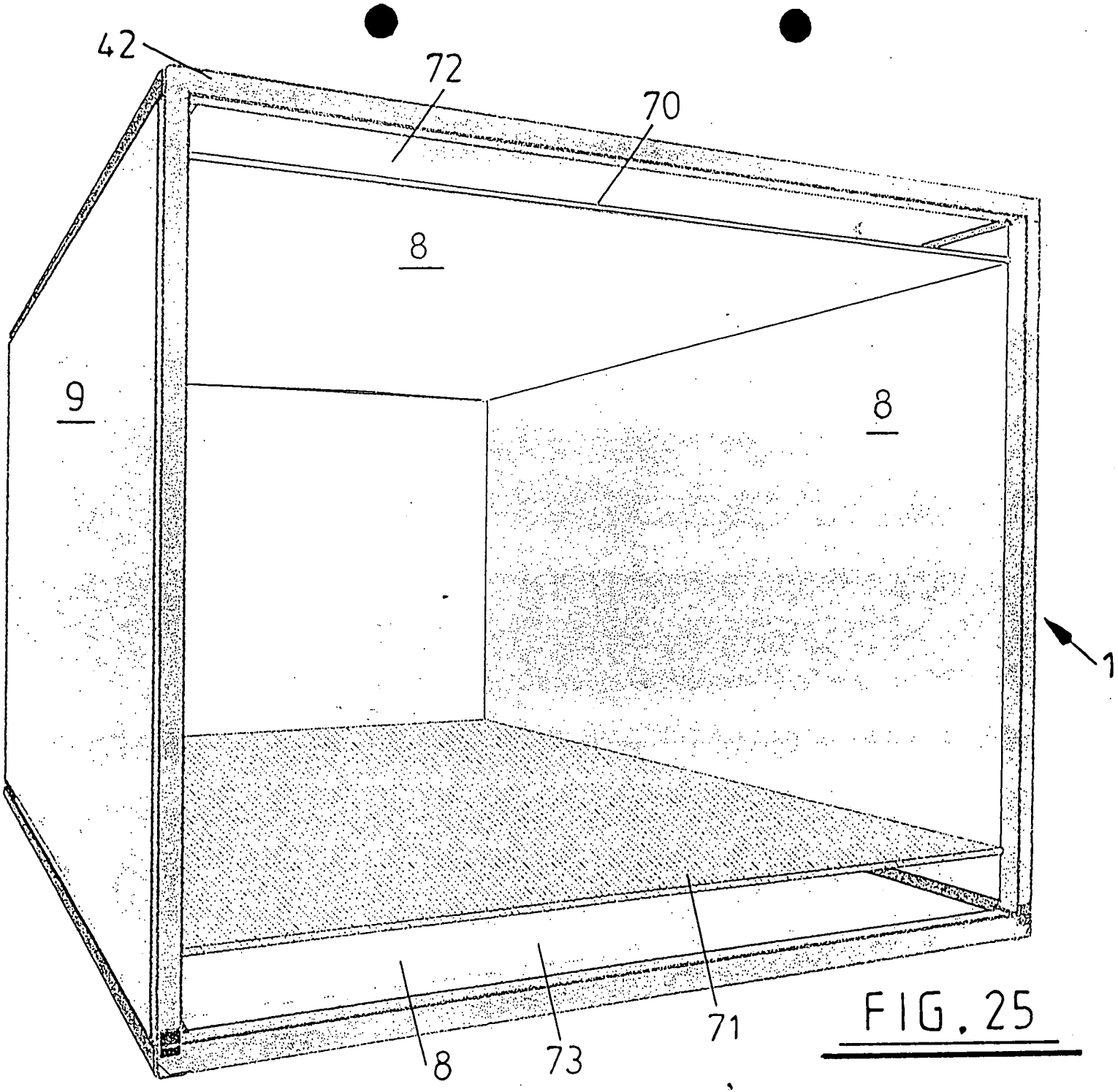

FIG. 25

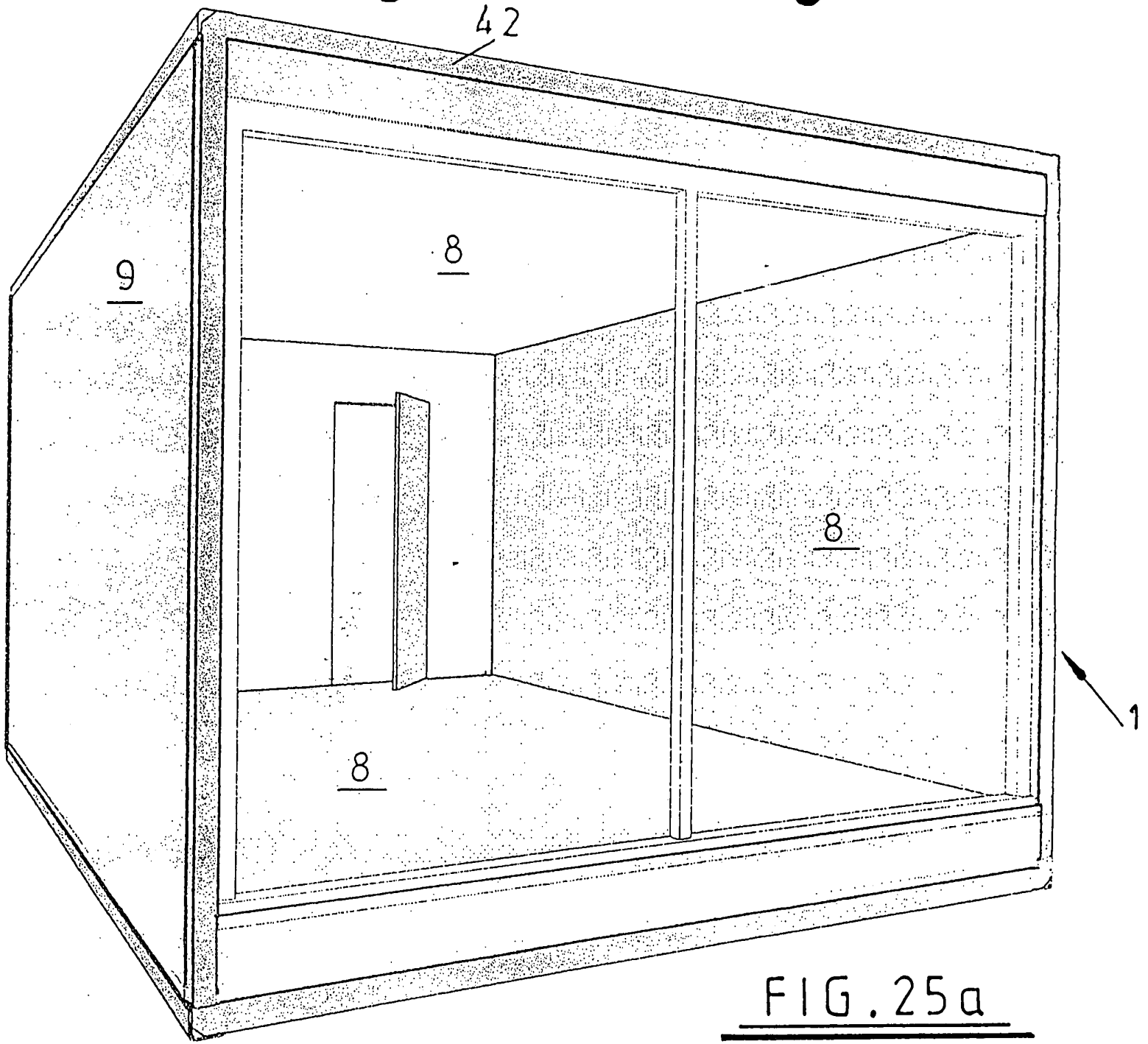

FIG. 25a

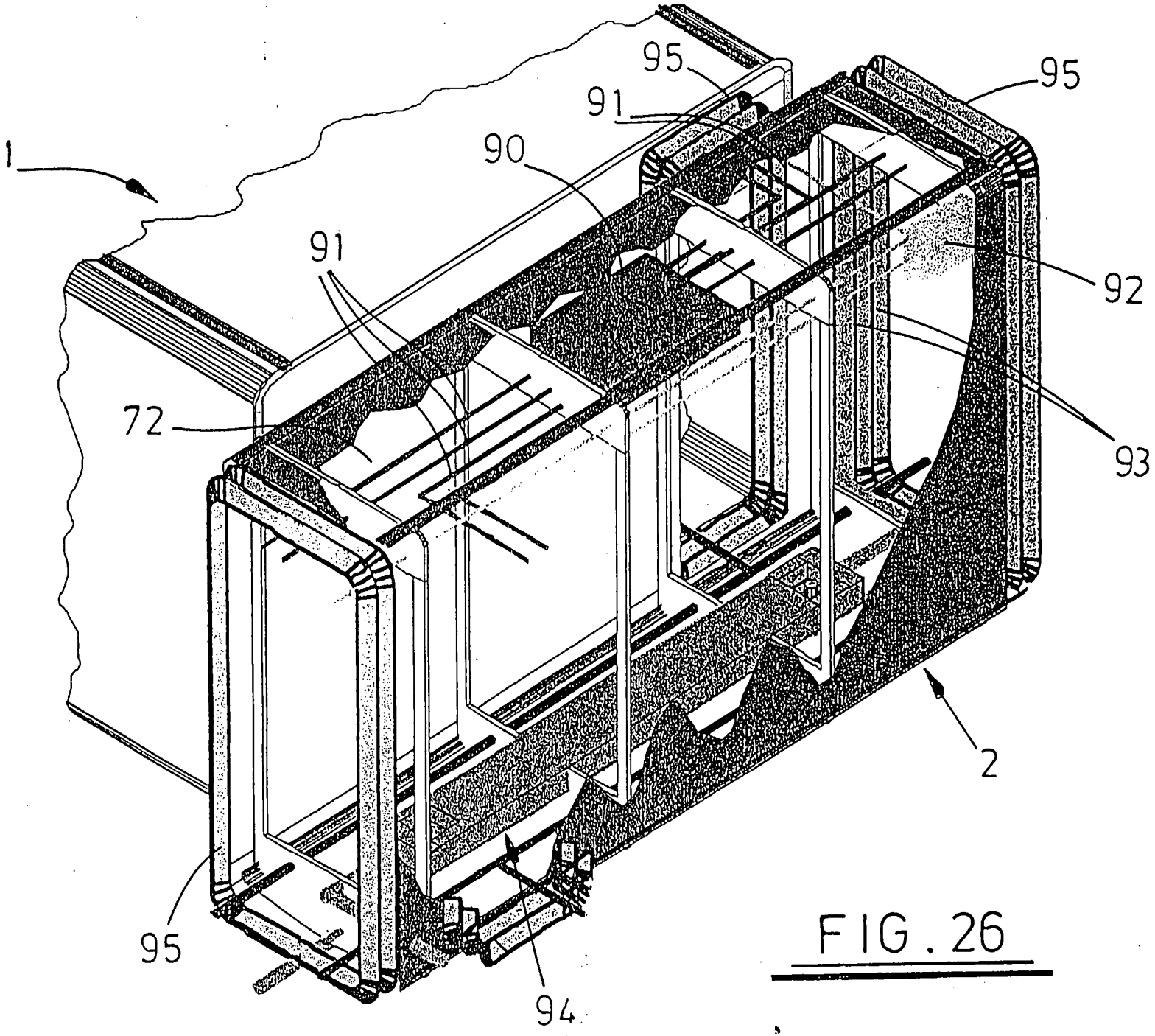

FIG. 26

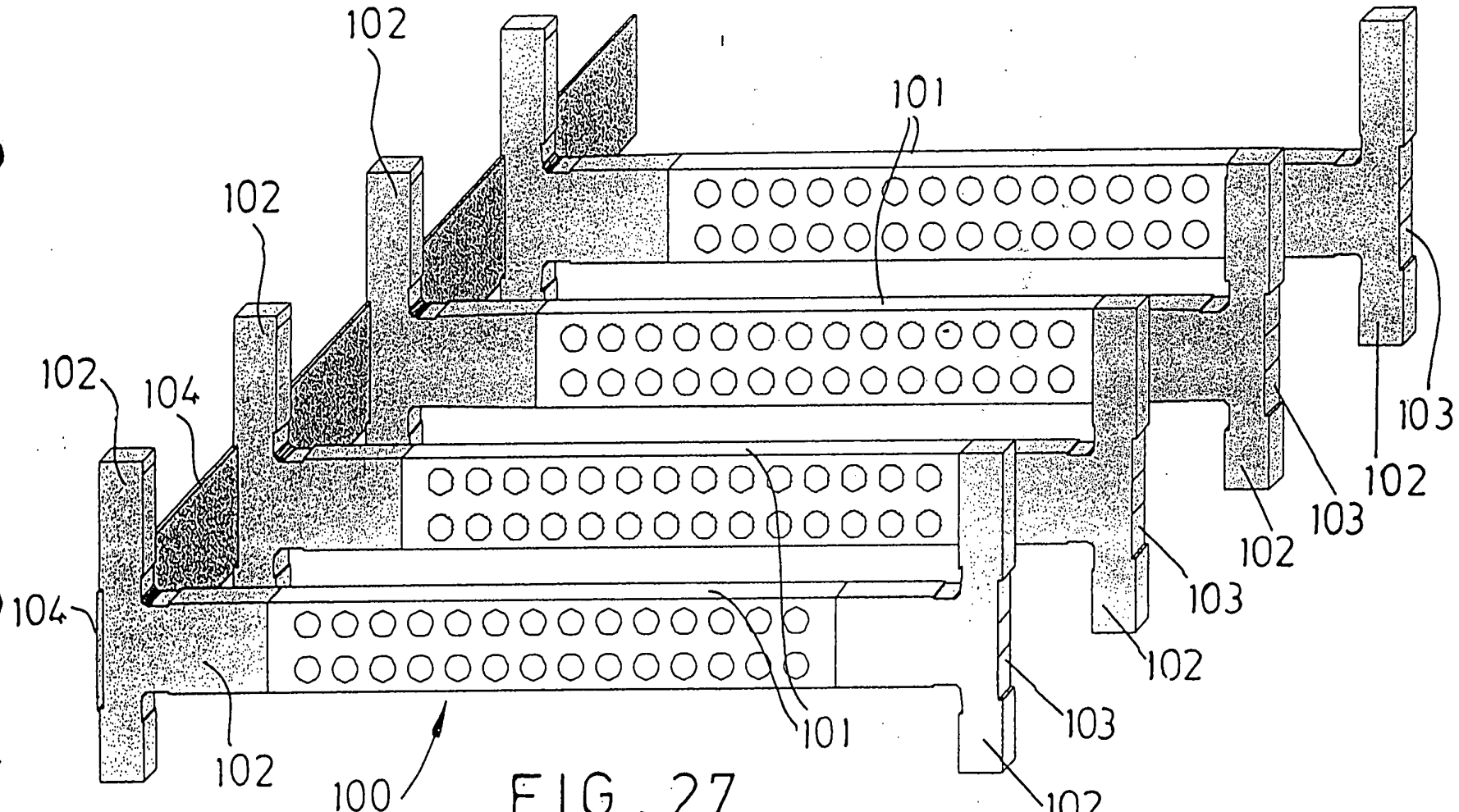
102
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FIG. 27

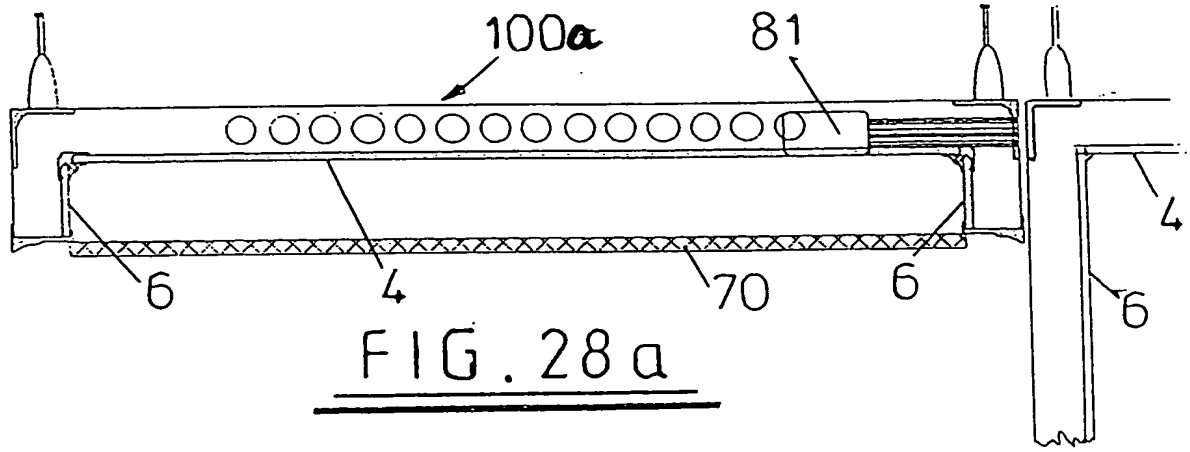


FIG. 28a

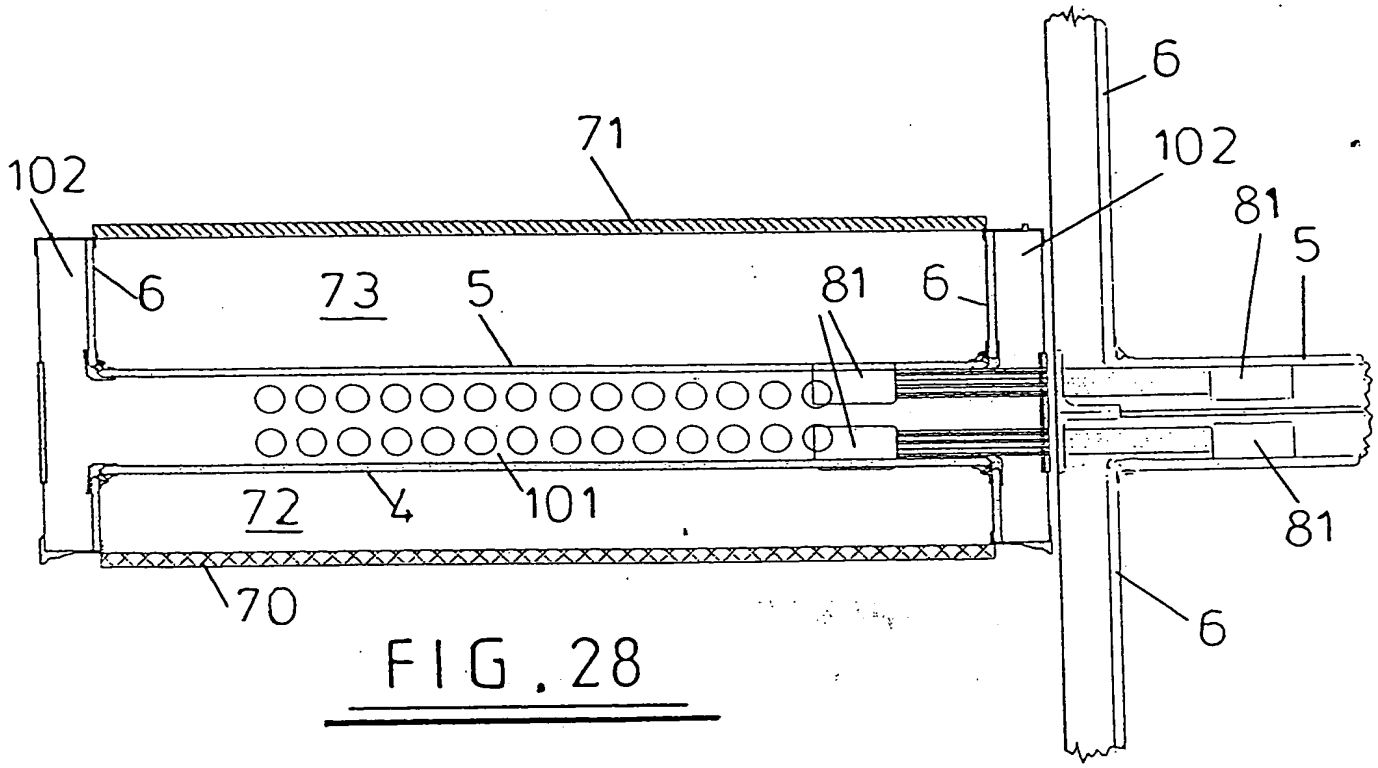


FIG. 28

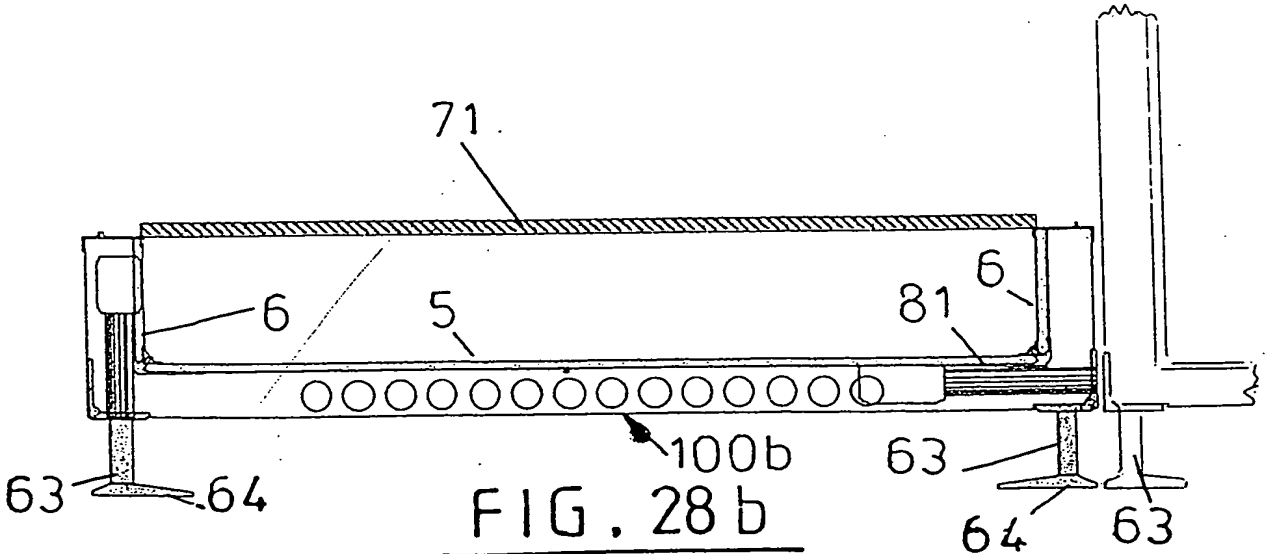


FIG. 28b

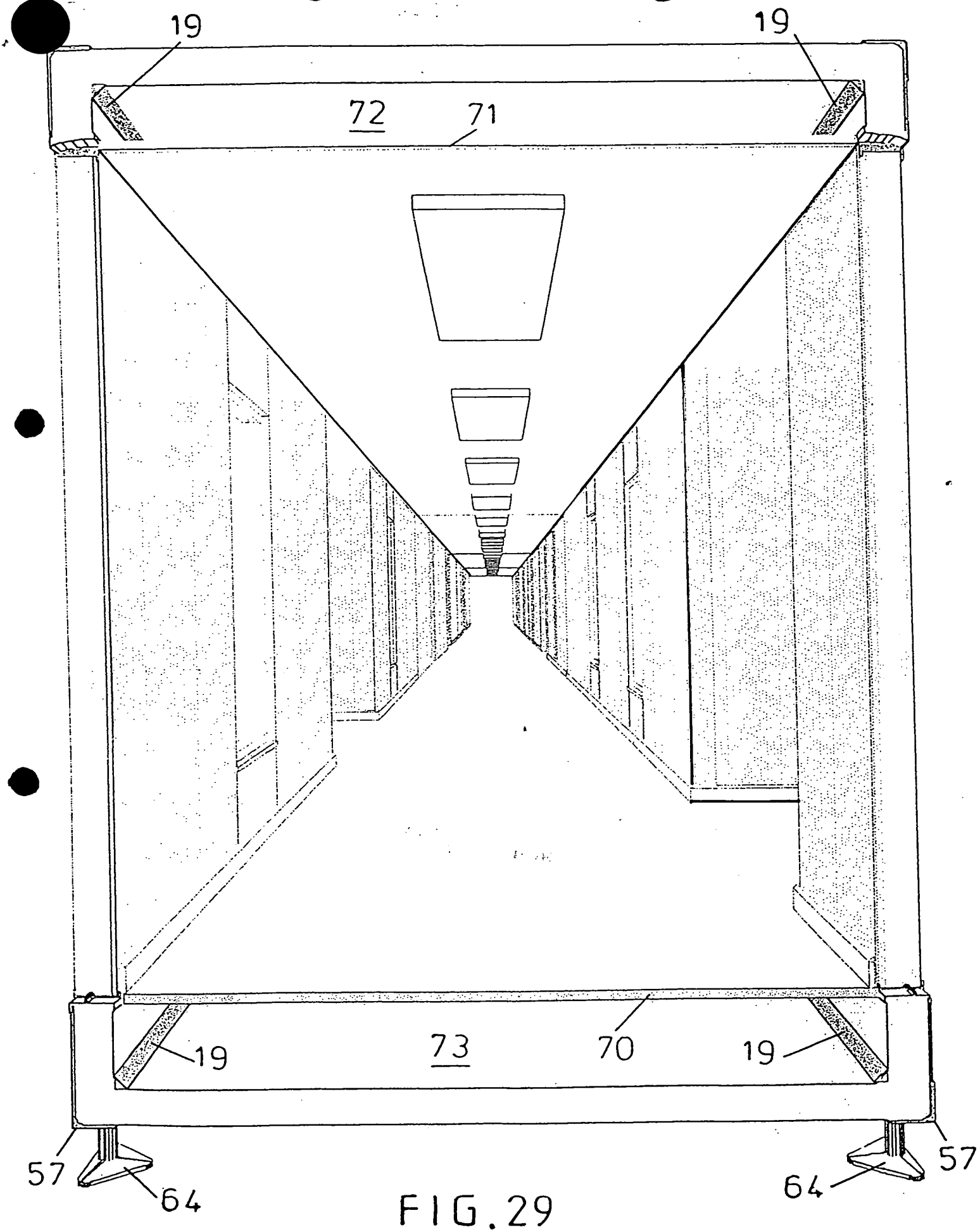


FIG. 29

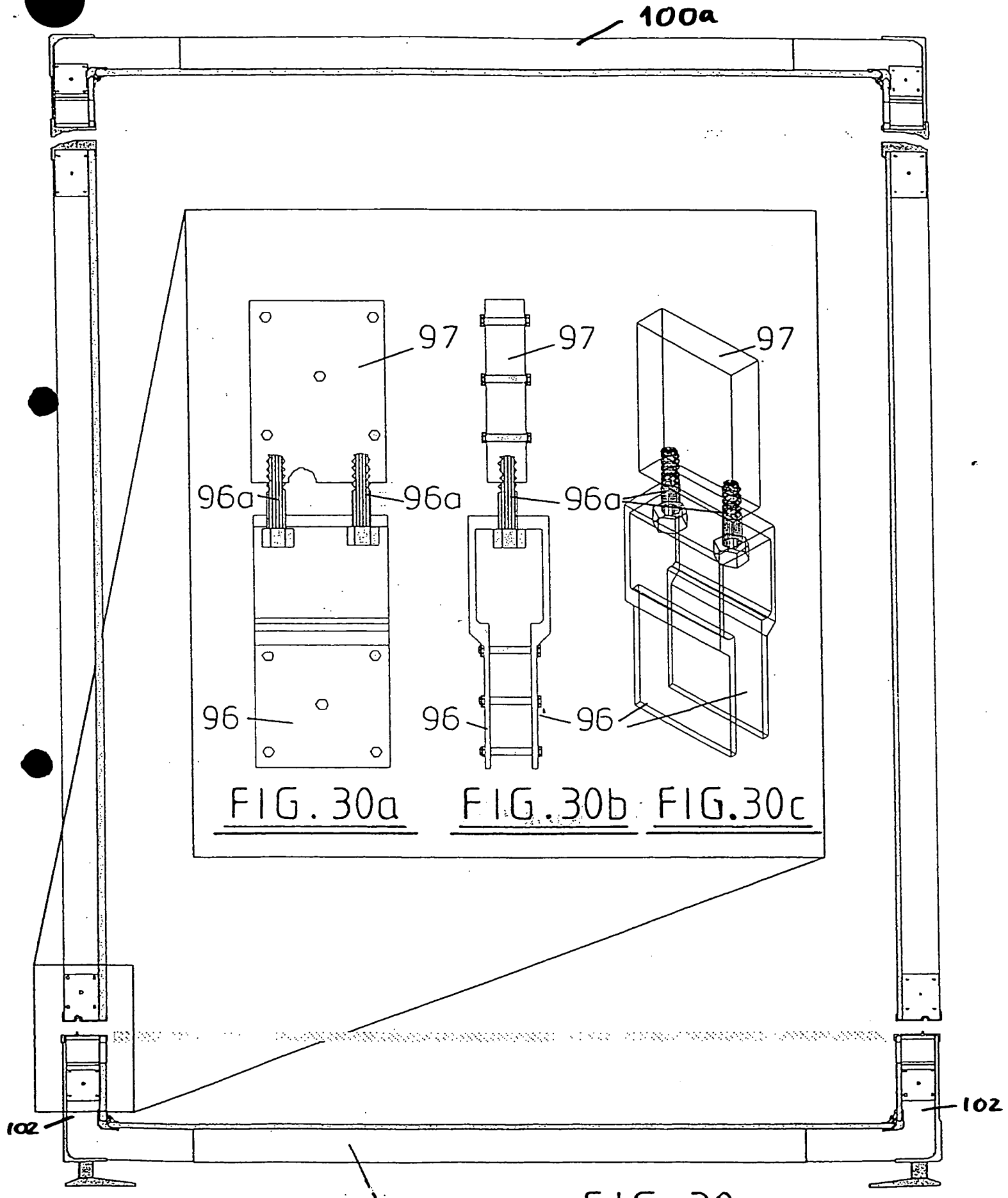
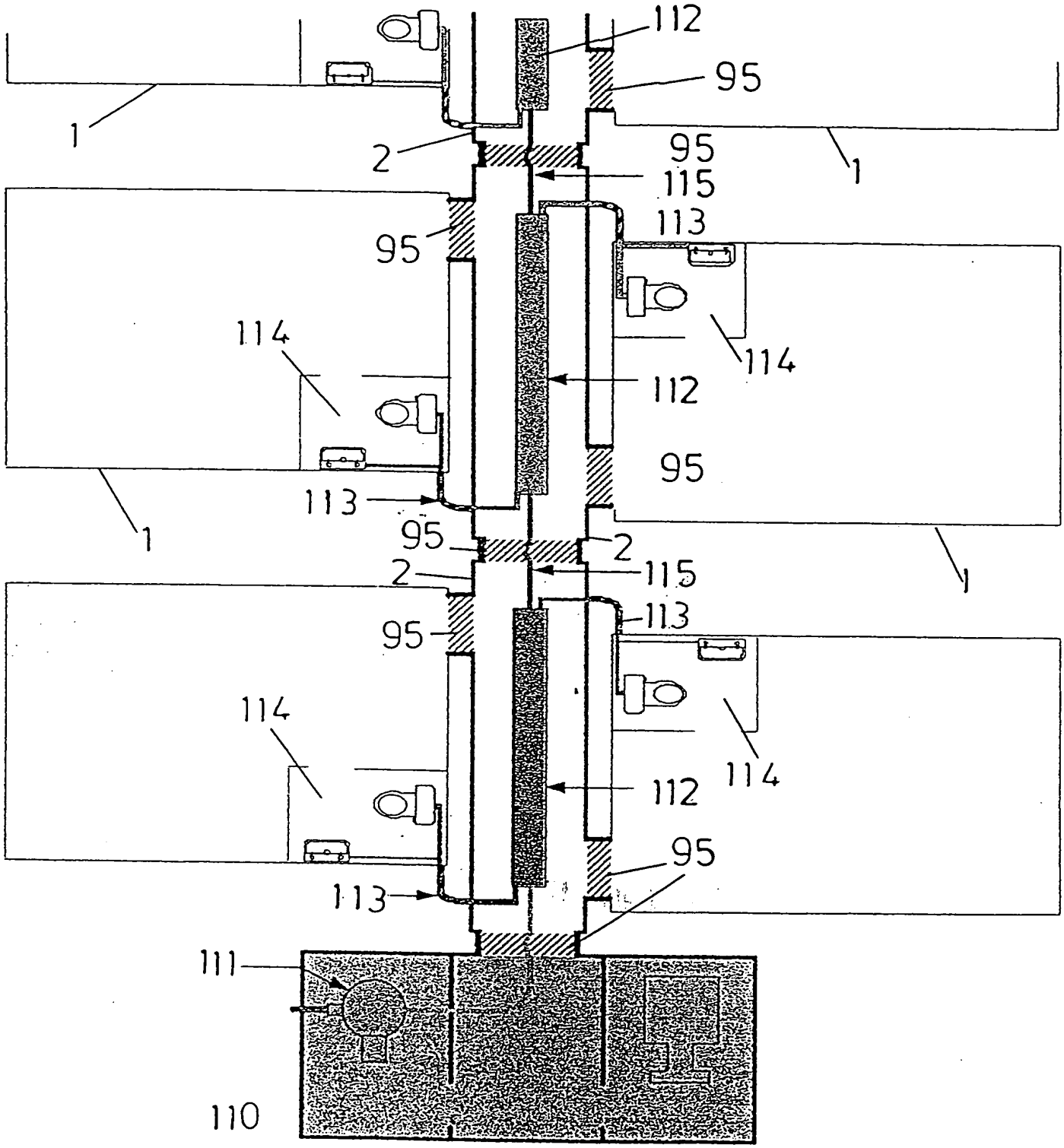


FIG. 30a FIG. 30b FIG. 30c

FIG. 30


112
95
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110

FIG. 31

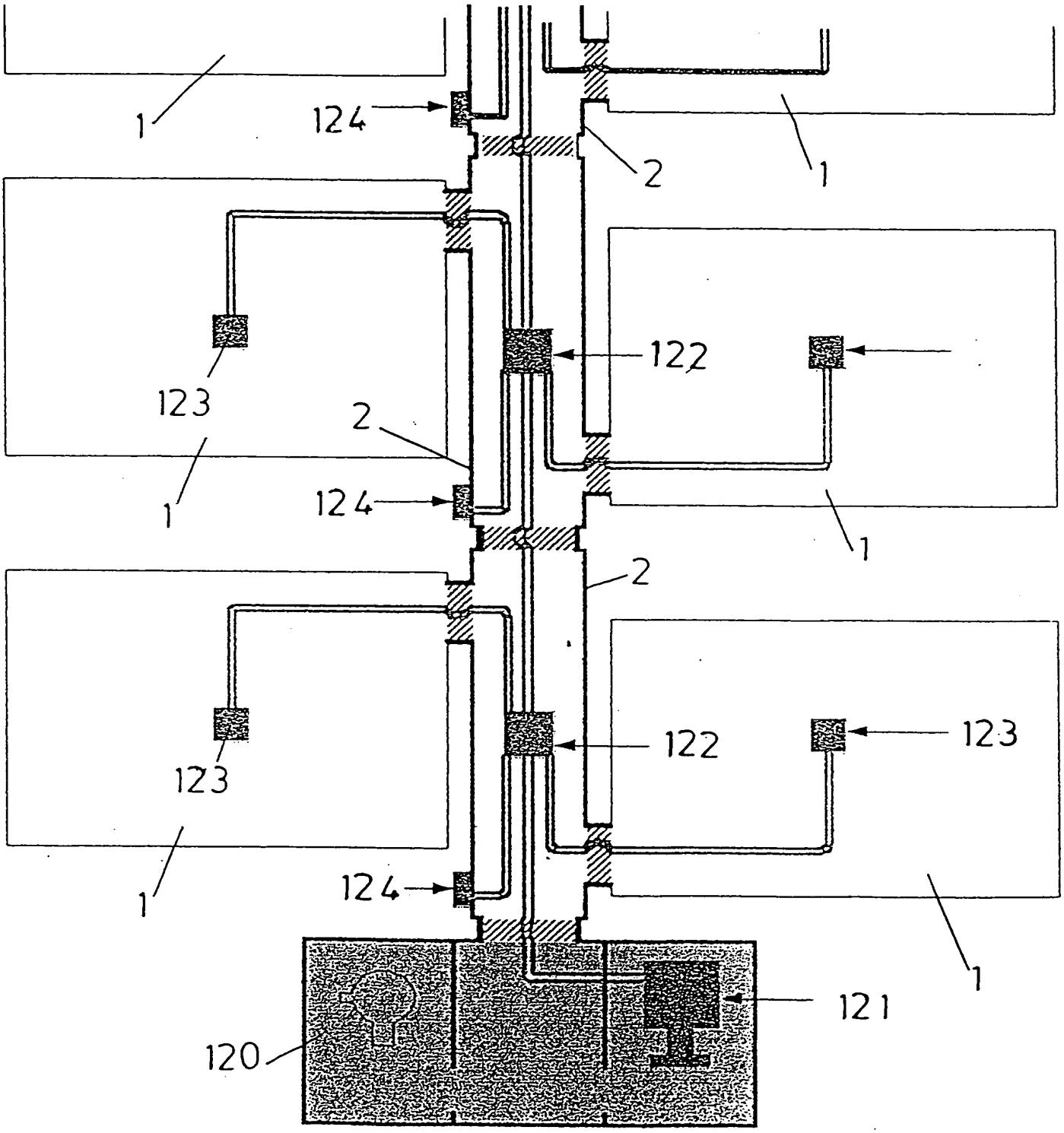

FIG 32

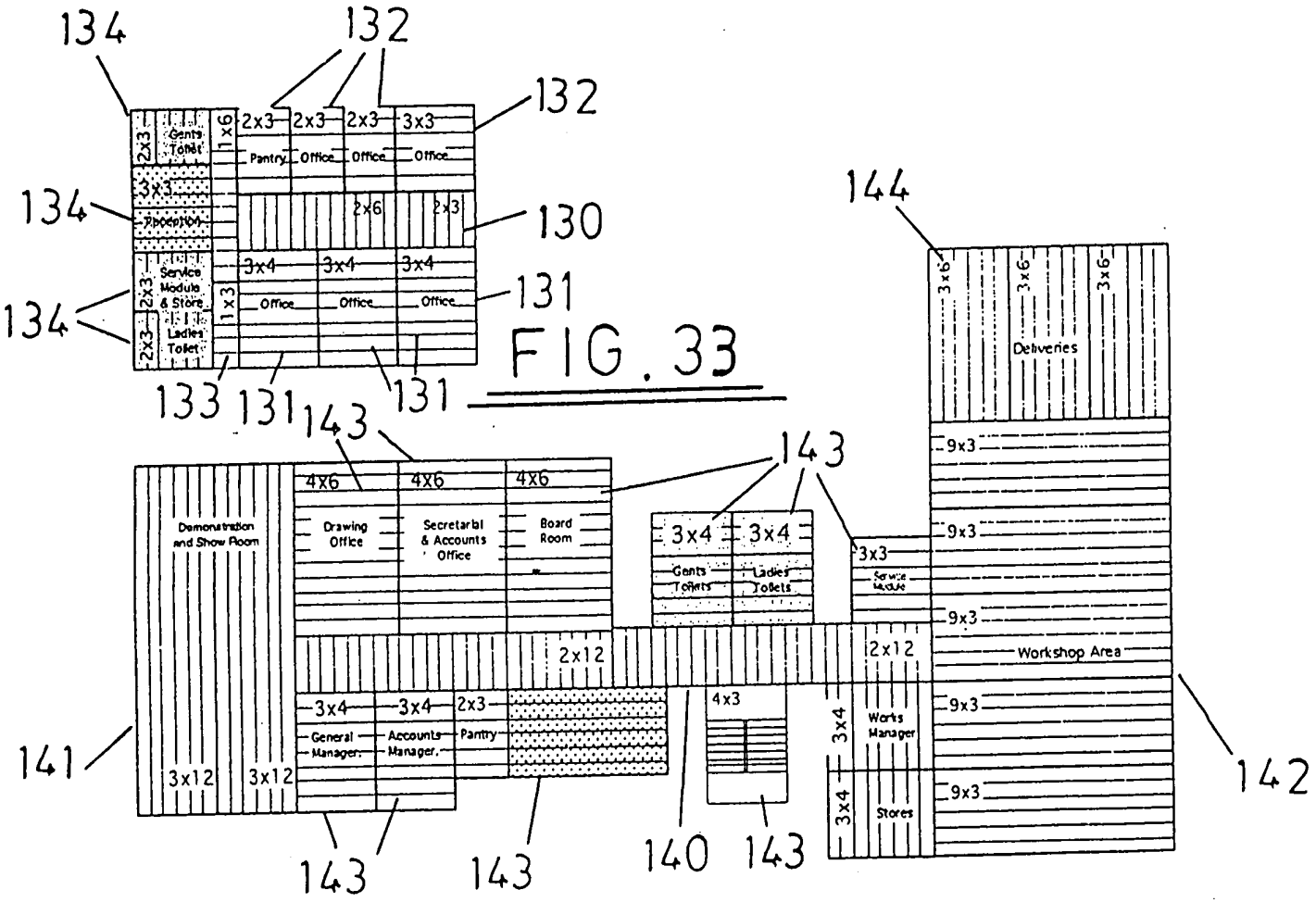
134
132
132
134
130
134
131
133
131
131
Gents Toilet
Pantry
Office
Reception
Service Module & Store
Ladies Toilet
2x3
3x3
1x6
3x4
1x3
2x6
144
143
143
141
142
140
143
143
Demonstration and Show Room
Drawing Office
Secretarial & Accounts Office
Board Room
Gents Toilets
Ladies Toilets
Service Module
Deliveries
Workshop Area
Works Manager
Stores
General Manager
Accounts Manager
Pantry
3x12
4x6
3x4
3x3
9x3
2x12
4x3

FIG. 33

FIG. 34

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